State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Planning

Initial Study and Mitigated Negative Declaration

GEORGIANA SLOUGH TEST BARRIER PROJECT TO PROTECT WINTER RUN SALMON

August 1992

Douglas P. Wheeler	**Pete Wilson**	**David N. Kennedy**
Secretary for Resources	**Governor**	**Director**
The Resources Agency	**State of California**	**Department of Water Resources**

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DEPARTMENT OF WATER RESOURCES
P.O. Box 942836
Sacramento, CA 94236–0001

STATE OF CALIFORNIA—THE RESOURCES AGENCY

PETE WILSON, *Governor*

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

AUG 26 1992

To: Distribution List:

Enclosed is the Initial Study and Mitigated Negative Declaration, Georgiana Slough Test Barrier Project to Protect Winter-Run Salmon. The project will consist of temporary installation of a rock, gravel, and sand barrier at the head of Georgiana Slough to improve the survival of downstream migrating winter-run smolts. The proposed schedule of operation is to install the barrier beginning in mid-January, begin operation by February 1 and remove the barrier beginning April 30, 1993. If flood stages are forecasted, the barrier will be removed earlier. The barrier is to improve smolt survival by guiding them down the Sacramento River toward the ocean. The Delta Cross Channel is also to be closed for the duration of the test. The Initial Study documents the proposed design and operational criteria, potential impacts, and proposed mitigation measures.

The Department of Water Resources will conduct a public workshop to explain the project, respond to questions, and receive comments. The workshop will be held on September 16, 1992 at 7 p.m. in the Isleton Community Center, 208 Jackson Boulevard, Isleton California 95641.

If you have any comments or questions regarding this project and its potential effects, please write to:

Stein Buer, Project Manager
Division of Planning
Department of Water Resources
P. O. Box 942836
Sacramento, California 94236-0001

The comment period will end Thursday, October 1, 1992. If you have any questions, please call me at (916) 653-1099 or call Stein Buer at (916) 653-6628.

Sincerely,

E. F. Huntley

Edward F. Huntley, Chief
Division of Planning

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Planning

Initial Study and Mitigated Negative Declaration

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Douglas P. Wheeler **Secretary for Resources** **The Resources** **Agency**	**Pete Wilson** **Governor** **State of** **California**	**David N. Kennedy** **Director** **Department of** **Water Resources**

D—002212

D-002212

State of California
The Resources Agency
Department of Water Resources

Mitigated Negative Declaration for GEORGIANA SLOUGH TEST BARRIER PROJECT To Protect Winter Run Chinook Salmon

The Project. The Georgiana Slough Test Barrier project will consist of temporary test installation of a rock, gravel, and sand barrier at the head of Georgiana Slough to improve the survival of downstream migrating winter run smolts. The proposed schedule is to install the barrier beginning in mid–January, begin operation by February 1, 1993, and remove the barrier beginning April 30, 1993. The barrier is expected to improve winter run smolt survival by guiding them down the Sacramento River toward the ocean. The Delta Cross Channel is also to be closed for the duration of the test.

About 8,000 cubic yards (16,500 tons) of material would be placed in Georgiana Slough using a barge mounted clamshell dredge. The barrier would extend across the full 200–foot width of the channel. It would have a trapezoidal cross section typical of an earthfill dam, a crest elevation of about 11 feet, a top width of about 10 feet; a bottom width of about 150 feet; and side slopes of about 2:1, horizontal to vertical. Lighted floating buoys and warning signs would alert boaters of the barrier's presence.

A barge mounted crane would be available to lift small boats over the barrier with minimum delay. A floating dock on each side of the barrier would allow boaters to disembark and cross the barrier while their boats are lifted across. If affected boaters and marina operators indicate during the comment period that the proposed period of closure will create significant impacts, the barrier could be partially or fully removed earlier than planned.

The crane would also be available to excavate the barrier in case of excessive flows in the Sacramento River. Georgiana Slough is a component of the Sacramento River Flood Control Project, with a flood design capacity of 20,600 cfs. The proposed criterion for removal of the test barrier would be a forecasted stage of 25 feet for the Sacramento River at I Street.

Two culverts, one 48 inches in diameter, the other 72 inches in diameter, with gates on the upstream end, would be embedded in the barrier to provide a potential means for water quality control. If there is serious degradation of water quality due to the reduction of flow from the Sacramento River into Georgiana Slough, the flap gates could be lifted open to allow limited flow into the slough. The culverts would be placed at about 6 to 8 feet below mean sea level.

The culverts could also be opened to provide an avenue for upstream fish migrant passage. The effectiveness of such culverts, in attracting and facilitating fish passage is unknown. An alternative mitigation measure could be the use of a temporary fish ladder. Monitoring would be implemented to test effectiveness for fish passage.

The project will include extensive monitoring of fisheries, water levels, and water quality. If the monitoring program reveals any unexpected significant adverse environmental impacts, these impacts will be mitigated, or if necessary, the barrier will be removed prior to the scheduled removal date.

The Finding. The project, which incorporates appropriate mitigation measures, will have no significant impact on the environment.

Basis for the Finding. Based on the Initial Study, it was determined that this project would not have significant adverse environmental effects. The project may significantly improve the survival of outmigrating winter run chinook salmon smolts. Proposed barrier design features and operational criteria will provide mitigation for potential adverse effects upon fisheries, recreational boating and navigation, flood control, water quality, and archaeological resources.

Specific mitigation measures include;

- Gated culverts for upstream migrant fish passage and water quality control:
- A barge mounted crane for boat passage of small craft and for potential early removal of barrier for mitigation;

- Warning criteria, standby equipment, and erodible barrier for flood control; and,
- Avoidance of and additional protective measures for archaeological resources in the vicinity of the proposed barrier.

The project includes extensive monitoring, reporting, and consulting with involved agencies; if the monitoring program reveals any unexpected significant adverse environmental impacts, these impacts will be mitigated including potential early removal of the barrier.

Therefore, this Negative Declaration is filed pursuant to Section 15073 of the Guidelines for Implementation of the California Environmental Quality Act.

E.F. Huntley

Edward F. Huntley, Chief, Division of Planning

Date 8/27/92

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Chapter 1. Introduction

Background

Sacramento River stocks of chinook salmon (*Oncorhynchus tshawytscha*), and particularly the winter run, are the subject of intense management efforts mainly directed at controlling harvest and overcoming the negative effects of water development, land use changes, and poor water quality in the drainage. Much of this effort, which includes complex fishing regulations, three major hatcheries, diversion screens, fish ladders, and instream flow and temperature management, is focused outside the Delta.

Within the Delta, efforts have focused upon reducing or rescheduling export pumping by the State Water Project (SWP) and the Central Valley Project (CVP), predation control in both export facilities, closing the Delta Cross Channel gates, and improved screening of agricultural diversions.

The proposed Georgiana Slough Test Barrier Project is designed to complement these efforts by improving the survival of out migrating smolts as they pass through the Delta on their way to the Pacific Ocean. While relatively little information is available on how conditions in the Delta affect winter run salmon, winter run smolts which are diverted into the central Delta will have a longer migration route and potentially greater exposure to the effects of the SWP and CVP export facilities. The National Marine Fisheries Service has stated that reducing the flow from the Sacramento River to the central Delta via the Delta Cross Channel and Georgiana Slough will have a beneficial effect upon the smolts (Wolcott, 1992).

The Georgiana Slough Test Barrier Project will block most of the Sacramento River flow from entering Georgiana Slough (Figure 1-1). Some controlled flow may be necessary for water quality control or to guide upstream migrants which must be helped past the barrier.

Other protective measures under consideration which may complement or substitute for the Georgiana Slough closure include possible diverter screens to guide a portion of the smolts into Sutter and Steamboat sloughs, barging of hatchery grown winter run smolts, acoustic screens, accelerating the predation control program in Clifton Court Forebay, screening agricultural diversions, and use of the Sacramento Ship Channel for winter run passage and other measures. These measures are also discussed in this initial study.

Additionally, negotiations stemming from Article VII of The agreement between DWR and the Department of Fish and Game (DFG) to offset direct fish losses in relation to the Harvey O. Banks Delta Pumping Plant are being coordinated with the Georgiana Slough Test Barrier Project.

Objective

The principal objective of the Georgiana Slough Test Barrier Project is to improve the survival of downstream migrating winter run chinook salmon smolt. Secondary objectives are to gather data about the effects of the test barrier on fish, water flows, and water quality, as well as to further evaluate barrier construction techniques.

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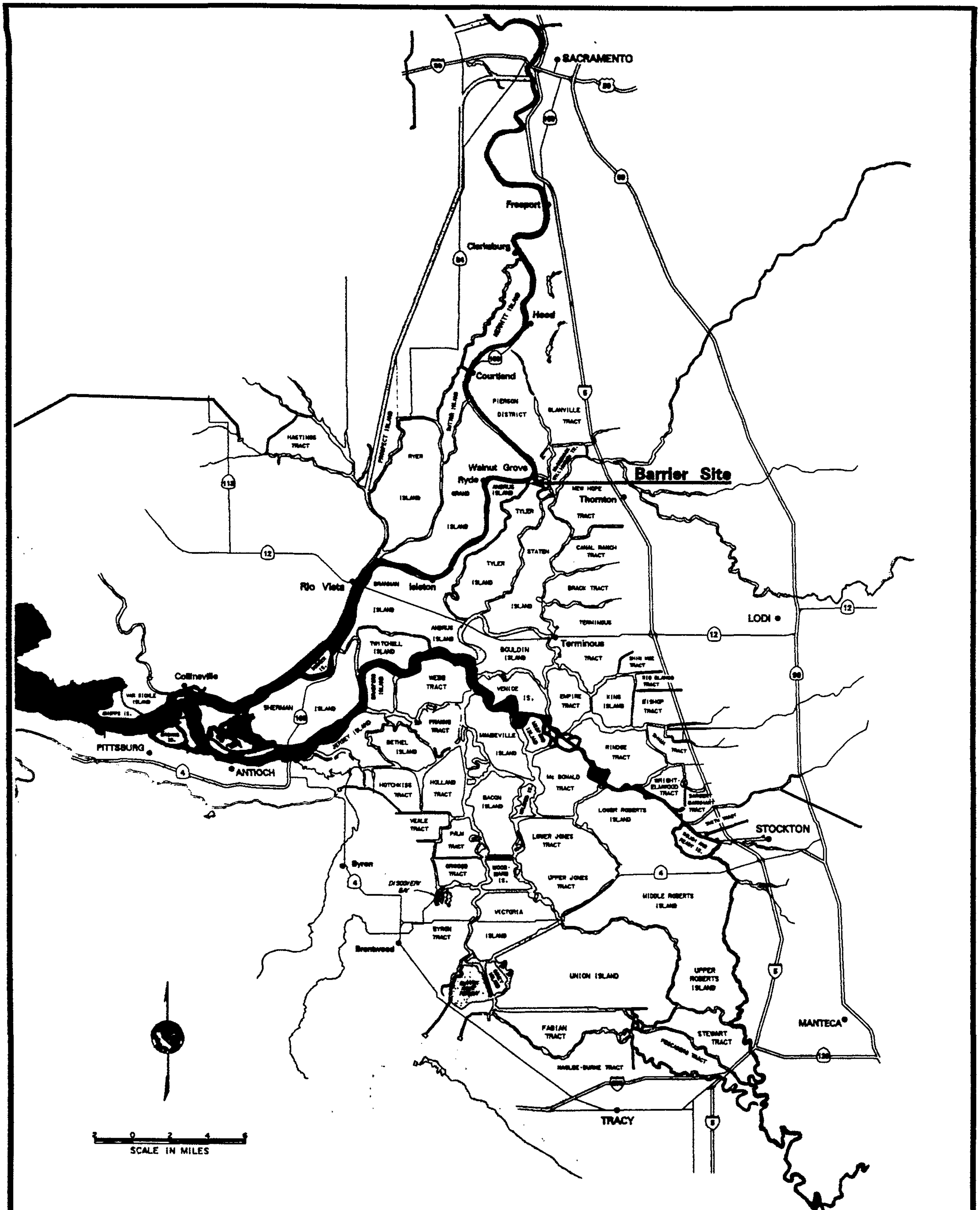


Figure 1–1. Sacramento–San Joaquin Delta

Chapter 2. Project Description

Proposed Project

This project consists of the installation of a temporary test barrier at the head of Georgiana Slough, at its junction with the Sacramento River (Figure 2–1). The proposed schedule of operation is to have the barrier installed by February 1, 1993, and removed beginning April 30, 1993. Due to the short time available for the project, only a rock aggregate barrier is considered feasible for this test installation.

The material in the proposed barrier will be composed of sand, gravel, and quarry rock of graded size to provide structural stability, adequate resistance to seepage flow, and yet be rapidly erodible if overtopped during a flood. The Georgiana Slough channel is about 200 feet wide and up to 25 feet deep in the vicinity of the proposed barrier. About 8,000 cubic yards (16,500 tons) of material would be placed using a barge mounted clam shell dredge. The barrier would have a trapezoidal cross section typical of an earthfill dam; a crest elevation of about 11 feet; a top width of about 10 feet; a bottom width of about 150 feet; and side slopes of about 2:1, horizontal to vertical (Figures 2–1 through 2–4). Lighted floating buoys, stop–logs, and warning signs would alert boaters of the barrier's presence. This design approach has the advantage of being simple to construct and remove, as well as its effectiveness in blocking flow, as demonstrated by the test barriers of the South Delta Water Management Program on the Old River and the Middle River.

Another barrier concept investigated was based on pilings spaced across the channel, with removable metal plates fastened to the pilings to form the flow barrier. Sheet pilings would be driven into the banks to facilitate sealing the dam at these uneven boundaries. Sandbags would be dropped along the base of the dam to seal the bottom. This option was judged to be not feasible because of time considerations.

Boat passage facilities will be provided for the smaller boats using Georgiana Slough. While several boat passage solutions have been considered, the most feasible would be to provide a barge mounted crane which could lift the boats over the barrier with minimum delay. A floating dock on each side of the barrier would allow boaters to disembark and cross the barrier while their boats are lifted across. Larger and heavier boats would be unable to pass the barrier for the 13 weeks the barrier is expected to be in place. If the barrier test proves successful, later designs could provide facilities for large boat passage.

The project operation would include provisions for removal in the event of severe flooding. Flood warning criteria have been developed which would trigger removal of the barrier. Department of Water Resources flood forecasting and operations staff would monitor the Sacramento River system and issue flood warnings as necessary.

The barge mounted crane, which would facilitate boat passage during normal flow conditions, would be used to remove the barrier in the event of threatening conditions. By keeping the crane on–site, mobilization time would be reduced. In the event of an intense flood on the American River system, as occurred in February 1986, the equipment would be unable to completely remove the barrier prior to the arrival of high water. In that case, the barrier would erode as water flows through the breach. The channel bottom downstream would be armored with riprap to prevent scour during the barrier erosion process.

Two culverts, one 48 inches in diameter, the other 72 inches in diameter, with flap gates on the upstream end, would be embedded in the barrier to provide a potential means for water quality control. If there is serious degradation of water quality due to the cessation of flow through the slough, the flap gates could be lifted open to allow limited flow through the slough. The culverts would be placed at about 6 to 8 feet below mean sea level.

The culverts could also provide an avenue for upstream migrant passage, although their effectiveness in attracting and facilitating passage is unknown. Another alternative which was investigated is the placement of a portable fish ladder over the barrier. A screened pump would be required to operate the ladder.

Monitoring and experimentation to define potential effects on vegetation and fisheries would also be required to fulfill the project objectives. The biological information gathered during the implementation of the Georgiana Slough Test Barrier Project will be used to guide ongoing efforts to find solutions to fishery resources and water use problems in the Delta.

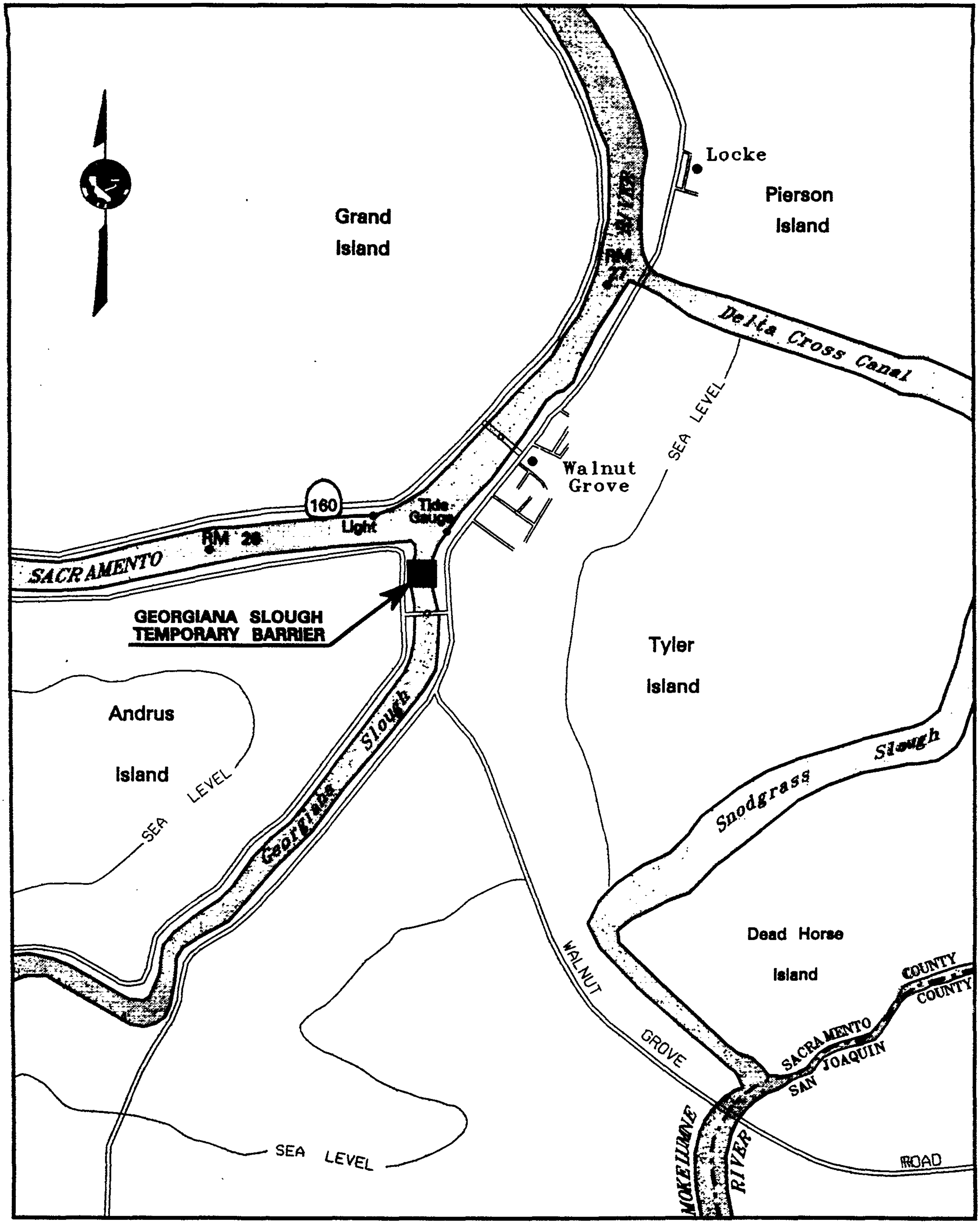


Figure 2-1. Site Map

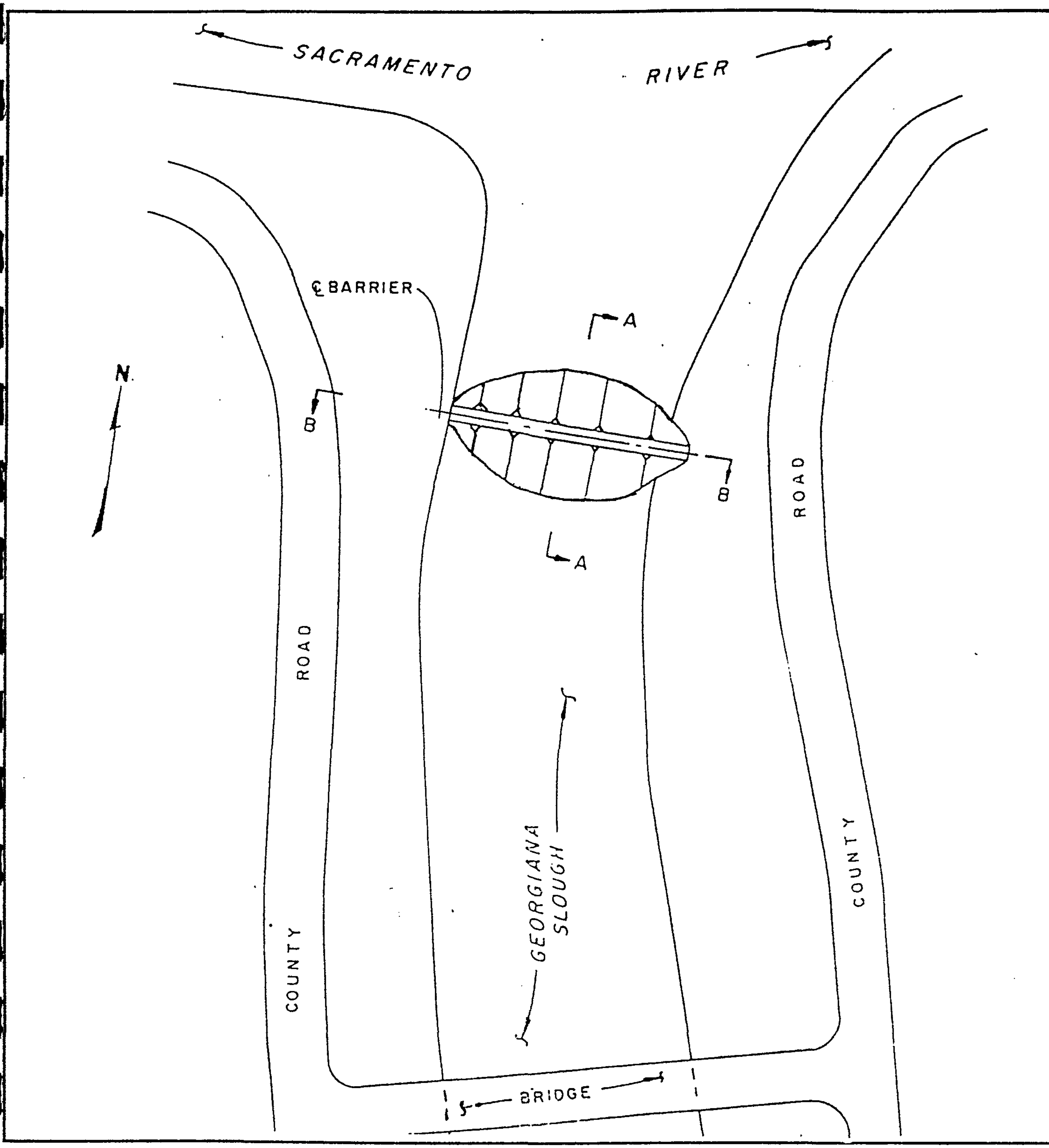


Figure 2–2. Plan View

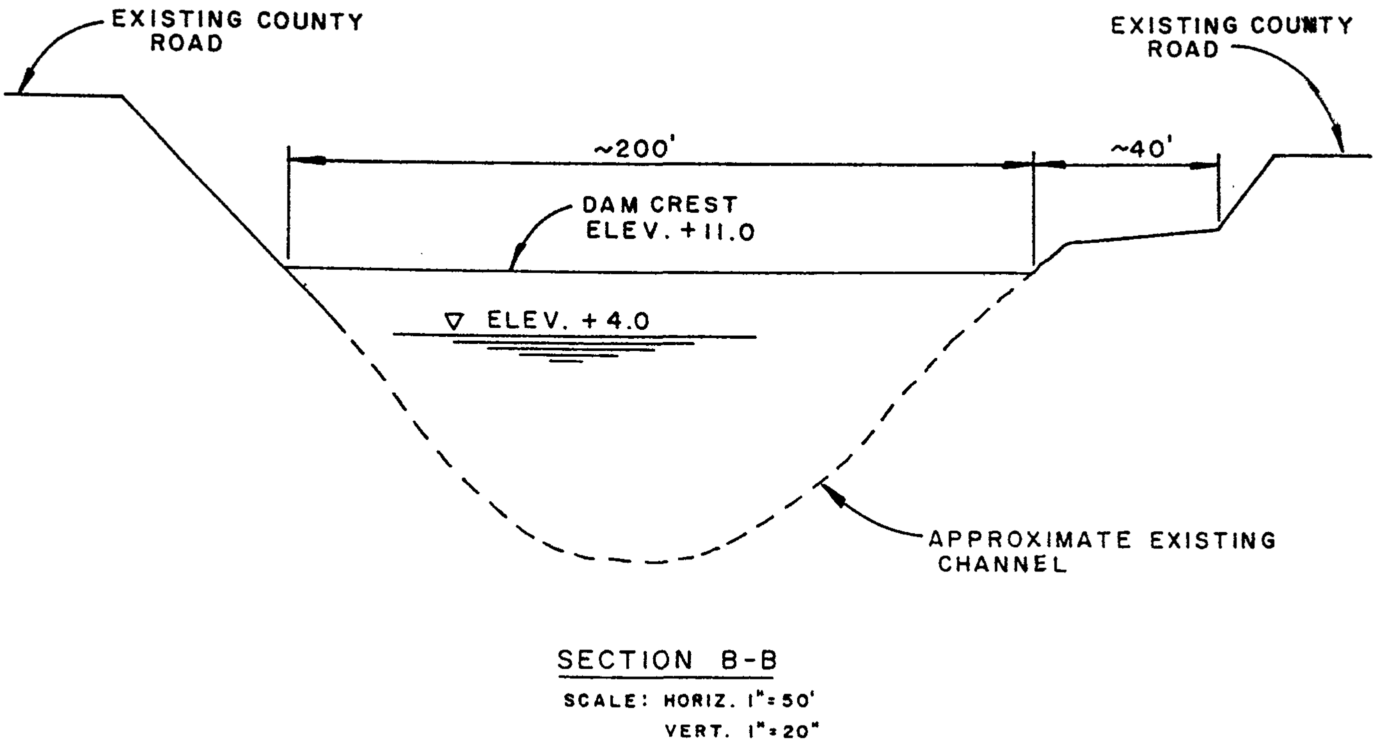


Figure 2–3. Channel Cross Section View

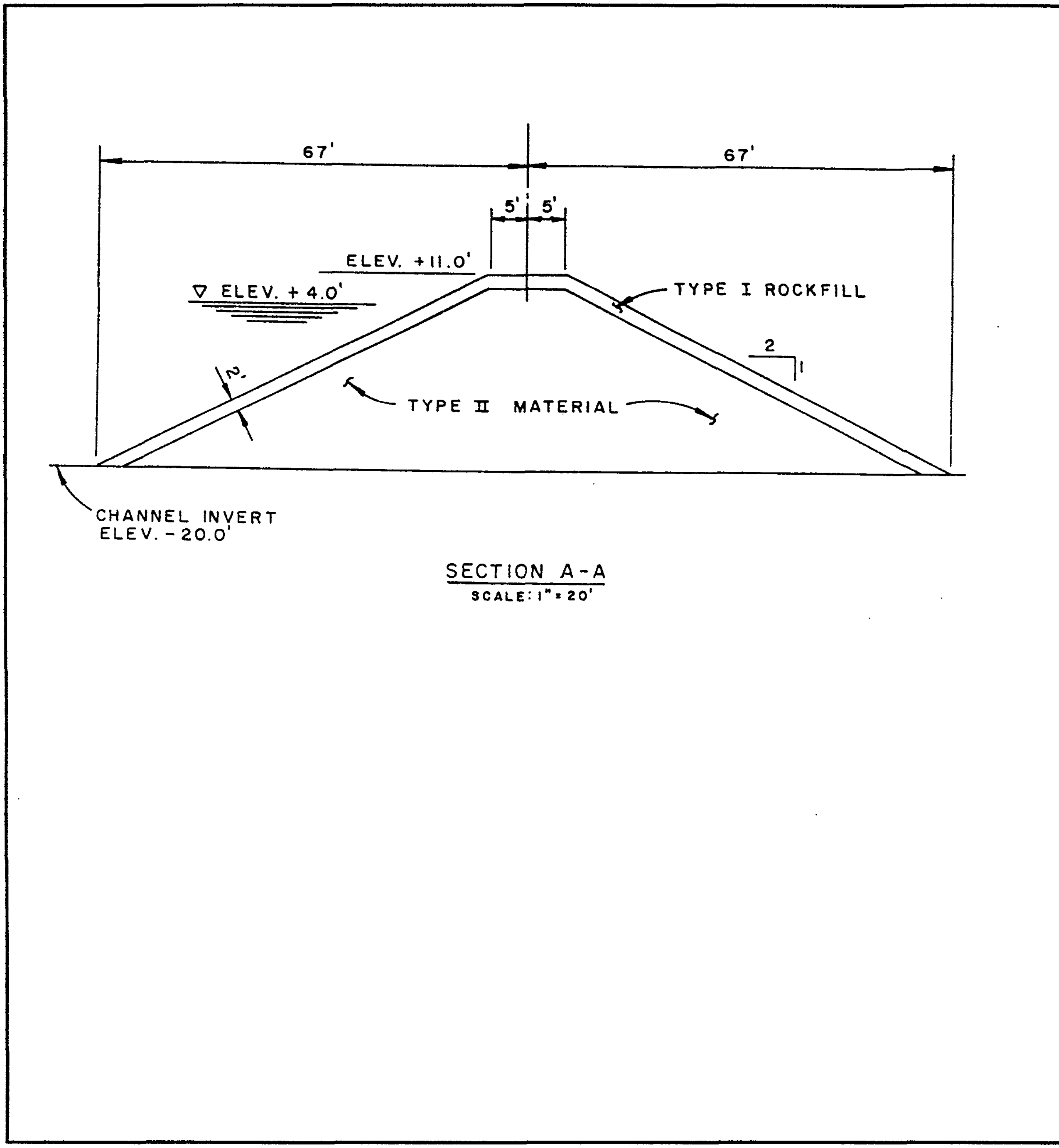
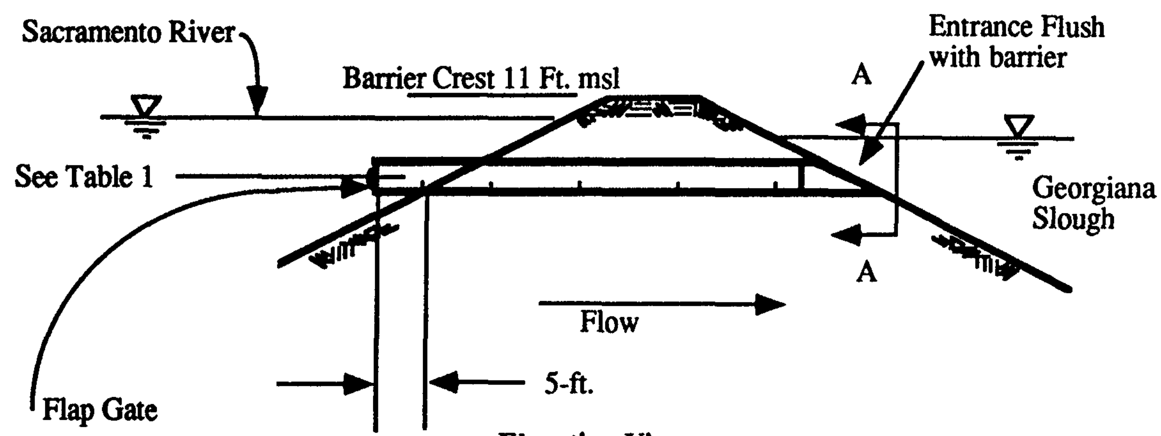


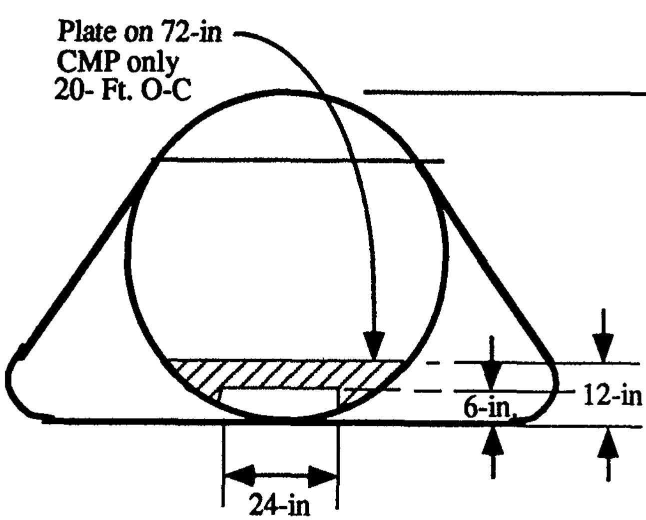
Figure 2–4. Barrier Cross Section View



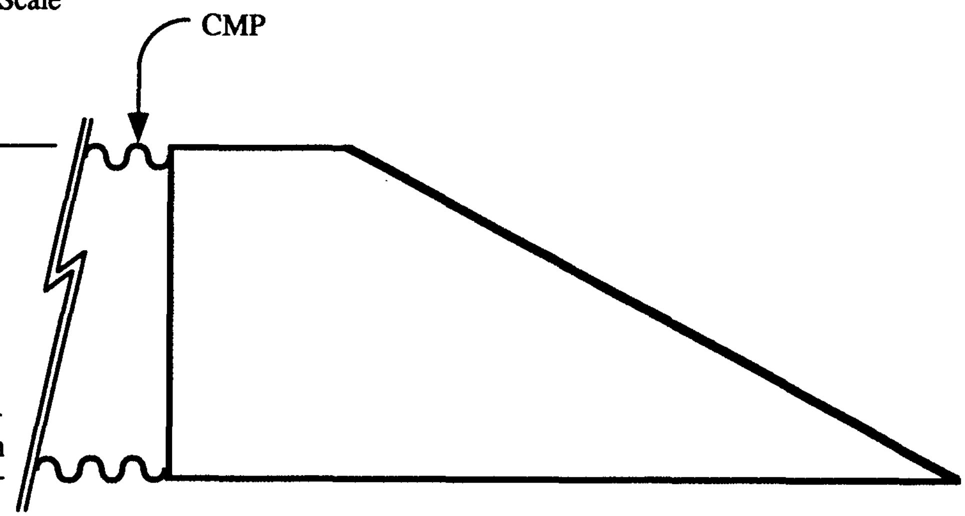
Elevation View
Not To Scale

Table 1
Centerline Elevations for CMPs

CMP Diam., in.	CL Elev,msl
48	- 6.0
72	-9.0



Section A-A
Entrance Transition Piece
(Rock Not Shown)



Side View, Entrance Transition

Figure 2-5. Upstream Migrant Passage Details
Georgiana Slough Test Barrier Project

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Alternative And Supplemental Actions

A variety of structural and management alternatives have been proposed as measures to help restore the winter run salmon population. In general, the alternative and supplemental measures described in this section are not mutually exclusive. Funding and staff limitations, as well as guidance provided by the National Marine and Fisheries Service (NMFS), DFG, and the U.S. Fish and Wildlife Service (USFWS), have led to the decision to give highest priority to the closure of Georgiana Slough, combined with operational constraints. Alternative and supplemental actions may be taken independently of this barrier project. They could help resolve conflicts with other environmental concerns, including flood control, local water quality, and boat passage. These concerns may require that the period of closure be altered, with appropriate adjustments in SWP and CVP operations, depending upon hydrologic conditions during the test period.

Alternative or supplemental measures to placement of the barrier at Georgiana Slough include:

- controlling predation in Clifton Court Forebay,
- reducing fish entrainment in Twitchell Island agricultural irrigation siphons and in Suisun Marsh diversions,
- testing acoustic fish screen techniques at the entrance to Georgiana Slough,
- barging of hatchery−reared winter run smolts,
- testing diverters to guide migrating smolts,
- testing diversion of a fraction of the Sacramento River into the Deep Water Ship channel to allow smolts to bypass Delta channels, and
- proposing operational constraints on the State Water Project and Central Valley Project export operations.

Predation Control in Clifton Court Forebay

While estimates of predation losses in Clifton Court Forebay vary widely, DFG, USFWS, and the NMFS agree that losses are significant, ranging as high as 90 percent for certain fish and certain times of the year. A variety of measures to reduce predation losses is now being explored. These include netting and removing large predatory striped bass from the forebay, bypassing the forebay under some conditions, and other measures. Survival of winter run smolts, which are entrained into the forebay, could be significantly improved with effective predatory striped bass control measures in place.

Reducing Fish Entrainment in Twitchell Island Agricultural Irrigation Siphons

The Department purchased about 80 percent of Twitchell Island to meet a variety of objectives, including SWP mitigation and wildlife enhancement, subsidence control, improving water quality, and reducing fish losses. Current Delta irrigation practices result in unquantified fish population losses as fish are entrained into irrigation water at unscreened intakes. Screening the intakes, or shifting irrigation schedules away from critical migration periods, may reduce direct losses of migrating winter run salmon smolts. This same alternative could also be applied to other agricultural diversions along the Sacramento River.

Testing Acoustic Fish Screen Techniques at the Entrance to Georgiana Slough

There is renewed interest in acoustic fish screening techniques, which, if effective, could provide a relatively economical and effective barrier under appropriate field conditions. An acoustic barrier would consist of fixed underwater sound generators, spaced closely enough to create a repellent sound field for the target fish species and age group. Such a concept could be used to guide fish into desirable channels or away from others. The Department and the U.S. Bureau of Reclamation (USBR) are evaluating a proposal to test acoustic fish screening methods at Georgiana Slough during a period when no barrier blocks the entrance.

Barging of Hatchery−Reared Winter Run Smolts

The technology for transporting fish by truck is well developed and is widely used to plant sport fish, return fish caught at fish screens, and to release hatchery−grown salmon and striped bass young. Trucking can reduce the mortality of hatchery−reared, winter run salmon, which would otherwise take place on their downstream migration. However, the ultimate success of such an operation may be limited because the migrants do not have the opportunity to experience the gradually varying chemical makeup of the natural environment of the stream as they move downstream. It is reasonable to assume that downstream mortality and straying of returning adults could be reduced if transport conditions involve minimal environmental shocks and more closely simulate the natural migration.

Barges could substitute for trucks, thus allowing a continuous exchange of water with the river during the transport period. The smolts would be less concentrated and exposed to air and sunlight. With this approach, it would be practical to adjust the transportation duration to reasonably simulate a natural migration period. Finally, the release into the selected receiving water could be done gently by opening slide gates as the barge moves through the water.

This approach would only be appropriate for hatchery–reared fish, which do not need to be captured before transport. It is not a preferred long–term alternative for assuring winter run salmon survival. However, it could serve as an effective interim measure to significantly reduce migratory losses of hatchery–reared fish and as a test for transporting naturally spawned smolts if an acceptable means of capturing these fish is found.

Testing Diverters to Guide Migrating Smolts

Diverters could be used both to guide fish into desirable channels and away from undesirable channels. For example, NMFS indicates that downstream migrating smolts should be prevented from passing into Georgiana Slough on their way to the sea. Conversely, there are indications that Steamboat Slough and Sutter Slough could provide safer migration routes than the Sacramento River because they prevent movement into the interior Delta channels.

Such diverters could be screens or solid plates, either extending to the bottom or only to a fraction of the channel depth. One promising design approach would be patterned after the trash rack built to protect the intake of the Tehama Colusa Canal at Red Bluff. The lower portion of the trash rack surface is angled into the channel, much like a snow plow. This design could be effective in diverting the downstream migrating smolts past the entrance to Georgiana Slough and other channels less desirable for smolt migration without inhibiting upstream passage of adult fish. Further experimentation is required to test the diverter concept before it can be considered a practical alternative to complete channel closure.

Such diverters would, to some extent, affect the channel flow and careful consideration would have to be given to channel and bank scour in the vicinity. The diverters would also have to be designed with the Delta's tidal fluctuations in mind.

Testing Diversion into the Deep Water Ship Channel

The Sacramento Deep Water Ship Channel connects to the Sacramento River just upstream from Rio Vista. A boat lock connects the channel to the Sacramento River at its upper end. This channel could potentially provide a migration pathway for winter run smolts which would bypass all Delta channels and agricultural diversions east of Rio Vista. The lock gates could be opened and an inflatable dam installed in the lock chamber to control the flow into the ship channel. This could be combined with a diverter to guide smolts into the lock structure.

Institutional and operational constraints for this alternative have not been explored. However, this alternative could have low construction costs, minimize impacts upon boating and navigation, and minimize migration hazards for the smolts.

Operational Alternatives

The National Marine Fisheries Service (Wolcott, 1992) has proposed a list of eight operational alternatives, which set export restrictions in combination with closure of the Delta Cross Channel and Georgiana Slough. These alternatives (Table 2–1) vary in the level of protection provided, but are all judged by NMFS to provide an acceptable level of protection for winter run. The proposed closure of Georgiana Slough is a component of alternatives D through H, as shown in the table. Installing the barrier in 1993 will affect which NMFS alternative may be selected.

Table 2-1. Juvenile Winter Run Chinook Salmon

Protective Alternatives for the Sacramento-San Joaquin Delta for all Water Year Types

Alternative	Close Delta Cross Channel	Close Georgiana Slough	Maximum Total Daily CVP/SWP Exports
A	2/1 thru 4/30	Open	2/1 thru 3/31 Vernalis Q 4/1 thru 4/30 75% Vernalis Q Plus 10% DOF when DOF ≥ 50000 cfs
B	2/1 thru 4/30	Open	SJR Jersey Pt. Q 0 to +1000 cfs 2/1 thru 4/30
C	2/1 thru 4/30	Open	3000 2/1 thru 4/30
* D	2/1 thru 4/30	2/1 thru 4/30	2/1 thru 3/31 Vernalis Q 4/1 thru 4/30 75% Vernalis Q Plus 10% DOF when DOF ≥ 50000 cfs
* E	2/1 thru 4/30	2/1 thru 4/30	D-1485 Salinity
F	11/1 thru 4/30	2/1 thru 4/30	D-1485 Salinity
G	1/1 thru 4/30	3/1 thru 4/30	3000 cfs 2/1 thru 2/29
* H	2/1 thru 4/30	2/1 thru 4/30	SJR Jersey Pt. Q 0 to -2000 cfs 2/1 thru 4/30

Related Projects

North Delta Program

The Georgiana Slough Test Barrier Project could be included as an interim fish protective measure implemented under the North Delta Program (NDP) or it could stand alone or be part of other programs. The North Delta Program represents parallel planning and environmental documentation to improve conditions in the northern portion of the Delta. The NDP represents a possible interim action or can be considered in accordance with Governor Wilson's water policy, which places all options for fixing the Delta on the table. The primary study area includes channel systems south of Sacramento, north of the San Joaquin River, east of Rio Vista, and west of Thornton. However, direct and indirect biological impacts will be analyzed from Oroville Dam downstream to the Delta and San Francisco Bay.

Primary objectives of the program are to alleviate flooding along the Mokelumne River, reduce reverse flow in the lower San Joaquin River, improve water quality, reduce fishery impacts, and improve water supply reliability. Secondary objectives are to improve navigation and enhance recreation. The planning and environmental documentation process for the NDP is currently underway. Alternatives being considered include increasing the hydraulic capacity of the North and South Forks of the Mokelumne River as a first phase. Later phases could include partial tide gate structures in the Sacramento River, Steamboat Slough, and Threemile Slough, and possibly a new Sacramento River connecting channel. *The North Delta Program Draft Environmental Impact Report/Environmental Impact Statement* was released in November 1990.

South Delta Water Management Program (SDWMP)

DWR and USBR are presently preparing a joint environmental impact document for the SDWMP. The action was initiated under the framework agreement (October 1986) among DWR, USBR, and the South Delta Water Agency (SDWA) that committed all three parties to work together to develop mutually acceptable, long-term solutions to the water quality and water supply problems of water users within SDWA. The principal objectives of the SDWMP are to improve water circulation and water levels for local agriculture and to increase the operational flexibility of the State Water Project to reduce impacts and increase reliability.

Evaluation of multipurpose alternatives to meet these objectives also takes into account fishery conditions, navigation, flood protection, recreational opportunities, and wildlife habitat.

The SDWMP represents parallel planning and environmental impact documentation to improve conditions in the southern portion of the Delta. The program includes a public review of problems, alternative solutions, impacts, and mitigation to provide information for selecting any action. This process will help bring to light the many interests and concerns related to water resources planning in the south Delta. The program also includes investigation of the cumulative effects of any corrective action, when coupled with other facilities statewide and in the Delta. *The South Delta Water Management Program Draft Environmental Impact Report/Environmental Impact Statement* was released in June 1990.

South Delta Agreements

In June 1986, DWR and SDWA signed a Joint Powers Agreement regarding interim measures to improve water level and circulation problems resulting from various factors, including the construction and operation of the SWP. The agreement included a plan for dredging the upper 5 miles of Tom Paine Slough, installing siphons in Tom Paine Slough, developing Clifton Court Forebay operational criteria, and constructing a weir in Middle River. Dredging Tom Paine Slough was completed in October 1986 and the siphons were completed in March 1989. The Middle River weir was installed in May 1987 and the center portion was removed at the end of September 1987. The removable weir portion is reinstalled each irrigation season.

In October 1986, a framework agreement for settling SDWA litigation was signed by DWR, USBR, and SDWA. The agreement included (1) negotiations for a long-term plan of physical or operational solutions, (2) provisions for cost-sharing and responsibilities for the implementation of the long-range plan, (3) interim actions, namely New Melones releases, to help improve the south Delta water supply, and (4) action to cancel the April 1987 trial date. The trial date was vacated and legal action was stayed. The negotiations spelled out in the framework agreement were recently completed and are being coordinated with the SDWMP environmental impact document work.

West Delta Water Management Program

The West Delta Water Management Program (WDWMP) addresses subsidence, flood control, water quality, water supply reliability, wildlife habitat, highways and utilities protection, and recreation. The importance of these issues to the west Delta, and to the Delta as a whole, has necessitated a broadened scope of planning. Because of its location at the confluence of the Sacramento and San Joaquin rivers, Sherman Island is important in protecting the reliability and the quality of Delta water supplies, as well as highways and utilities. For these reasons, Sherman Island is the focus of the WDWMP. Other smaller islands in the west Delta are also important for protecting the reliability and quality of Delta water supplies, as well as numerous other benefits.

The alternatives currently being pursued are wildlife management plans for Sherman Island and Twitchell Island. These plans, coordinated with other Delta planning, have the potential to develop a number of significant benefits, such as fish and wildlife enhancement, levee improvements for flood control, land management to slow subsidence, recreational opportunities, and better water supply management. To date, 2,800 acres have been acquired on Twitchell Island.

Los Banos Grandes Reservoir

In 1984, DWR completed a reconnaissance study of potential offstream storage sites south of the Delta. Such reservoirs could be used to store runoff pumped from the Delta during wet periods and delivered via the California Aqueduct. The report, *Alternative Plans for Offstream Storage South of the Delta,* recommended that future studies focus on the Los Banos Grandes Reservoir site, south of the existing San Luis Reservoir. Also in 1984, the Legislature authorized the Los Banos Grandes offstream reservoir and DWR began planning. The basic plan would be a SWP water supply facility with power generated by reservoir releases incorporated to the SWP power resource plan. A draft EIR/EIS was released in December 1990.

State Water Policy

The proposed test barrier in Georgiana Slough is consistent with the important components outlined in the Governor's April 6, 1992, Comprehensive Water Policy. Key elements of this policy include "fixing the Delta in both the near– and long–term." Solutions must address "fish and wildlife needs, efficiency and reliability of water export systems, water quality and various water uses, and physical integrity of Delta channels and levees."

The Governor called for the appointment of an Oversight Council, composed of members drawn from the urban, agricultural, and environmental sectors. This committee will guide the planning and decision making process. The Governor will also create a separate technical advisory panel. Governor Wilson said, "Any recommended long–term solution must be scientifically sound and guarantee protection for the Bay–Delta estuary."

The proposed test barrier may provide important short–term benefits to the winter run, and provide the information helpful to develop long–term solutions.

Chapter 3. Environment, Consequences, And Mitigation

3.1 Location And Land Use

Affected Environment

The Sacramento–San Joaquin Delta and San Francisco Bay estuary, comprised of the Delta, Suisun Marsh, and the San Francisco Bay system, provide an ideal environment for agriculture, industry, transportation, recreation, and major fish and wildlife populations. It also serves as a key link in the life cycle of a large portion of California's anadromous fish populations, including steelhead, sturgeon, and four races (or "runs") of chinook salmon.

The Sacramento and San Joaquin rivers meet in the Delta, intermingling with smaller tributaries in a 700–mile maze of leveed channels, flowing westward past Suisun Marsh, into San Pablo Bay, and then into San Francisco Bay to the ocean.

The Delta has legal boundaries established in California Water Code Section 12220 and are shown in Figure 3.1–1. The Delta is bordered by the cities of Sacramento, Stockton, Tracy, and Pittsburg. The 738,000 acres in the Delta are part of the largest estuary in California. The former wetlands have been reclaimed into more than 60 islands and tracts, largely devoted to farming (about 520,000 acres), which produce an average gross income of about $375 million.

The 700 miles of waterways in the Delta are lined by about 1,100 miles of levees, which protect the islands and tracts, almost all of which lie at or below sea level.

The proposed barrier is located within the north Delta area. Major hydrographic features of the area are the Sacramento River and adjoining sloughs, the Mokelumne River, Dry Creek, and the Morrison Creek stream group. The Sacramento River and adjoining Sloughs, including Steamboat, Sutter, Elk, and Georgiana Slough, are part of the federal Sacramento River Flood Control Project. These channels are lined with federal project levees, and protected by extensive flood control works upstream, including reservoirs and bypass systems. The Mokelumne River and tributaries drain about 2000 square miles, with mostly unregulated flow entering the north Delta from the east . The flows from the Mokelumne River, Dry Creek, the Cosumnes River, and the Morrison Creek stream group converge in the vicinity of Walnut Grove, then drain to the San Joaquin via the north and south forks of the Mokelumne River.

The Delta Cross Channel, constructed by the USBR in 1951, is about 3,000 feet upstream from the mouth of Georgiana Slough. The Delta Cross Channel has two 60–foot gates at the Sacramento River to augment the natural transfer of water southerly from the Sacramento River, via the north and south forks of the Mokelumne River. The gates are normally closed when Sacramento River flows exceed 25,000 cfs to limit flood danger in the channels of the Mokelumne River system. However, floodwaters from the Sacramento River overtopped the closed gates during the February 1986 flood, slightly adding to the flooding in the Mokelumne River system.

The communities of Walnut Grove and Locke lie immediately to the north–east of the project site, on the Sacramento River. Courtland is about eight miles upstream. Isleton is about nine miles downstream along the Sacramento River.

The proposed project site falls within the boundaries of three Reclamation Districts: Reclamation District 554, which includes Walnut Grove, on the north–east portion of Tyler Island; Reclamation District 563, which includes the rest of Tyler Island; and Reclamation District 556, which includes the north–east portion of Brannan–Andrus Island.

Public roads line both sides of Georgiana Slough at the proposed barrier site. River Road follows the east bank, while Isleton Road follows the west bank. A swing bridge, operated by Sacramento County, crosses the slough about 700 feet downstream from its mouth. Sacramento County also operates Tyler Island Bridge, which crosses the slough about eight miles downstream.

A residence, with a floating dock, is located on the east bank next to River Road, just upstream from the bridge. A stream gage, operated by the U.S. Geological Service (USGS), measures Sacramento River stages just upstream from the junction with Georgiana Slough. It is accessed via a catwalk from River Road.

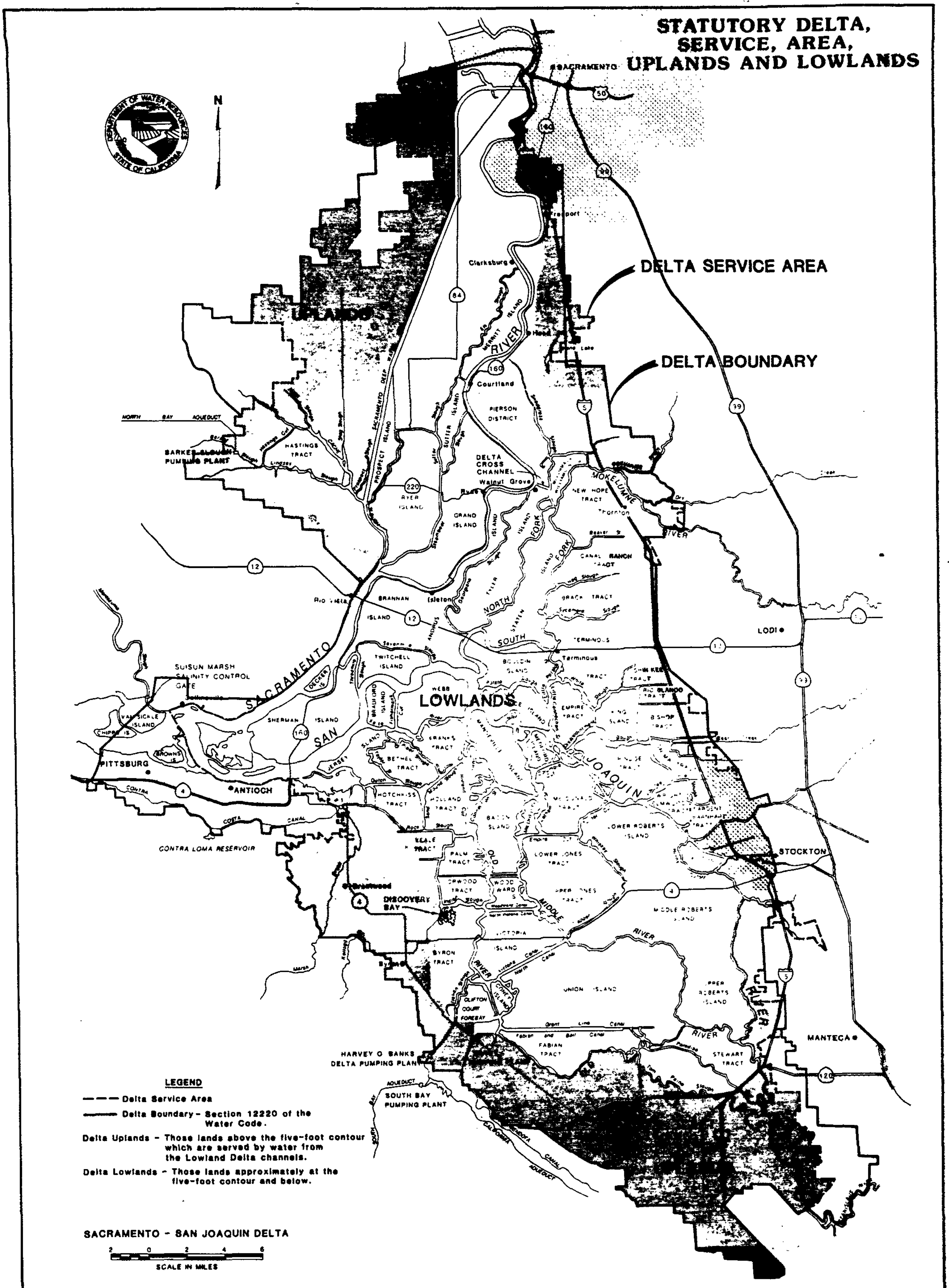

Figure 3.1–1. Statutory Delta, Service Area, Uplands and Lowlands

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Environmental Consequences

The proposed barrier construction would be completed using a barge–mounted crane with dragline or clamshell to move the barrier material from barges. For the anticipated two weeks required to construct the barrier, there would be noise generated by the equipment, dust could be released during the dumping operation, and the slough would be closed to boat traffic.

Mitigation

Normal construction practices will be followed to minimize noise, disruption, and dust. If dust becomes a problem, the barrier material will be sprayed with water during the dumping operation. No impacts upon local traffic patterns are anticipated.

3.2 Climate

Affected Environment

The climate of the Delta is Mediterranean, with warm, dry summers and cool, moist winters. The annual average temperature is about 60o F, with extremes ranging from 100° F in summer June–September) to 30° F in winter (December–March). Average summer and winter temperatures are 75° F and 45° F, respectively.

In spring and summer, winds from the Pacific Ocean enter the Delta through the Carquinez Strait, at times reaching 50 miles per hour. This marine air inflow moderates what would otherwise be a hot, dry climate. During winter, land breezes prevail, and temperatures vary from 43° to 82° F. During late fall and winter, a dense ground fog periodically covers the Delta for several days at a time.

Average annual precipitation in the north Delta is about 18 inches. Rainfall during fall and winter accounts for most of this precipitation, with little occurring during summer. The local rainfall is supplemented by irrigation water readily available from the surrounding waterways. The growing season is long. Stockton has an average of 324 frost–free days per year, and farmers often plant and harvest two crops during the year.

Environmental Consequences and Mitigation

No effects upon climate are anticipated.

3.3 Navigation

Affected Environment

The Delta waterways are important transportation corridors, with varying seasonal use and in accordance with need. Commercial transport, levee maintenance activities, law enforcement, fire suppression, and recreation are among the activities affected by the navigability of Delta channels.

The U.S. Coast Guard's concerns are mainly for the safety and visibility features employed while the slough is closed. DWR is in the process of coordinating and consulting with the Coast Guard's 11th District in Long Beach, California to obtain approval of the navigational aids that will be employed at the site. The official weekly publication of the Coast Guard, *Notice to the Mariners*, will notify all interested parties of the nature and the time of closure.

Discussions with major barge operators indicate that the main function of the barge traffic in Georgiana Slough is levee maintenance and repair work for the western portion of the Tyler Island and the eastern portion of the Andrus Island. There is no planned levee work scheduled during the period of closure. However, emergency and unplanned levee repair may be necessary.

Georgiana Slough is also an important waterway for emergency response boats (Personal Communication, Chief George Apple of Isleton Fire Department, July 1992). Boats equipped with fire fighting and medical equipment respond to occasional emergencies at waterfront homes and marinas along the slough. DWR staff is coordinating with Walnut Grove and Isleton fire departments.

Environmental Consequences

The proposed barrier will prevent barge traffic, sheriff's patrol, and fire–fighting boats from moving to and from the Sacramento River. This could impact flood fighting capabilities, as well as public safety during the period of closure, with potential damage to land and structures if fires occur.

Mitigation

Possible mitigation measures for the temporary loss of navigation access through the head of Georgiana Slough include use of alternative road patrols or placement of emergency response vessels on both sides of the barrier. These issues will continue to be discussed with involved public safety officials.

Table 3.4–1. Commercial Recreation Facilities, North Delta

1. Courtland Docks	17. Tunnel Trailer Park	33. Korth's Pirates Lair Marina
2. Morgan's Landing	18. Sids Holiday Harbor	34. Moores Riverboat
3. Steamboat Landing	19. Snug Harbor	35. Willow Berm Boat Harbor
4. Steamboaters Resort	20. Hidden Harbor	36. Lighthouse Resort
5. Islands Marina	21. Vieira's Resort	37. Rancho Marina
6. Golden Gate Island Resort	22. Cliff House	38. Sycamore Park
7. The Boathouse	23. Ernie's	39. Perry's Boat Harbor
8. Walnut Grove Merchants Dock	24. Riverside Inn & Marina	40. B&W Resort Marina
9. Deckhands	25. Ox Bow Marina	41. Tower Park Marina
10. Delta Country Houseboats	26. The Spot	42. Camp - A - Float
11. Walnut Grove Marina	27. Owl Harbor	43. Herman & Helen's
12. New Hope Landing	28. Bruno's Island	44. Uncle Bobbie's
13. Wimpy's Marina	29. Blue Heron Harbor	45. King Islands Marina
14. Giusti's	30. Spindrift Marina	46. King Island Houseboats
15. Ryde Hotel	31. Andreas Cove	47. Holiday Flotels
16. Ko — Ket Resort	32. Happy Harbor	48. King Island Resort
		49. Paradise Point Marina

3.4 Recreation

Affected Environment

The Delta's bountiful natural resources and close proximity to highly populated areas are among the reasons for its use as a major recreation area. Major population centers of the San Francisco Bay area, Suisun Bay area, Sacramento, and Stockton border the Delta. Its abundant water, fish, wildlife, cultural, and historical resources offer a variety of recreational opportunities such as boating, fishing, hunting, sightseeing, camping, picnicking, jet skiing, and just plain relaxing (Figure 3.4–1). The Delta's 50,000 surface acres of water is one of the largest bodies of protected cruising water in the western United States. In addition to the more than 700 miles of waterways and 60 leveed islands and tracts, the Delta retains approximately 800 unleveed islands, many of which feature wetlands, riparian forest, and unique historic features.

Georgiana Slough is an important connecting waterway between the Sacramento and San Joaquin River system. It features vegetated waterside berms, an exceptionally deep channel, and two swing bridges that allow for the passage of large cruisers and sailboats. Recreation along Georgiana Slough includes boating and fishing. Water skiing is not allowed because of a five mile per hour speed limit.

Closure of the slough would force boaters to either cancel trips through the slough, use the limited boat passage measures provided as mitigation for this project, or use other connecting waterways, including the Delta Cross Channel, Threemile Slough, and the junction of the San Joaquin and Sacramento rivers west of Sherman Island.

When the gates are open, The Delta Cross Channel provides a passage for smaller boats with a clearance requirement of less than 15 feet. It is likely that the Delta Cross Channel will be closed most of the time that the proposed Georgiana Slough barrier is in place, but the option of opening one of the gates during slack tide, when flow is negligible, is a potential mitigation measure.

Threemile Slough provides passage between the San Joaquin and Sacramento River channels, but is considered undesirable for most destination sites. A detour through Threemile Slough would add three hours or more to the travel time between marinas on the San Joaquin and Sacramento River systems. The detour also entails travel on the lower San Joaquin and Sacramento River channels, which are typically windy and choppy.

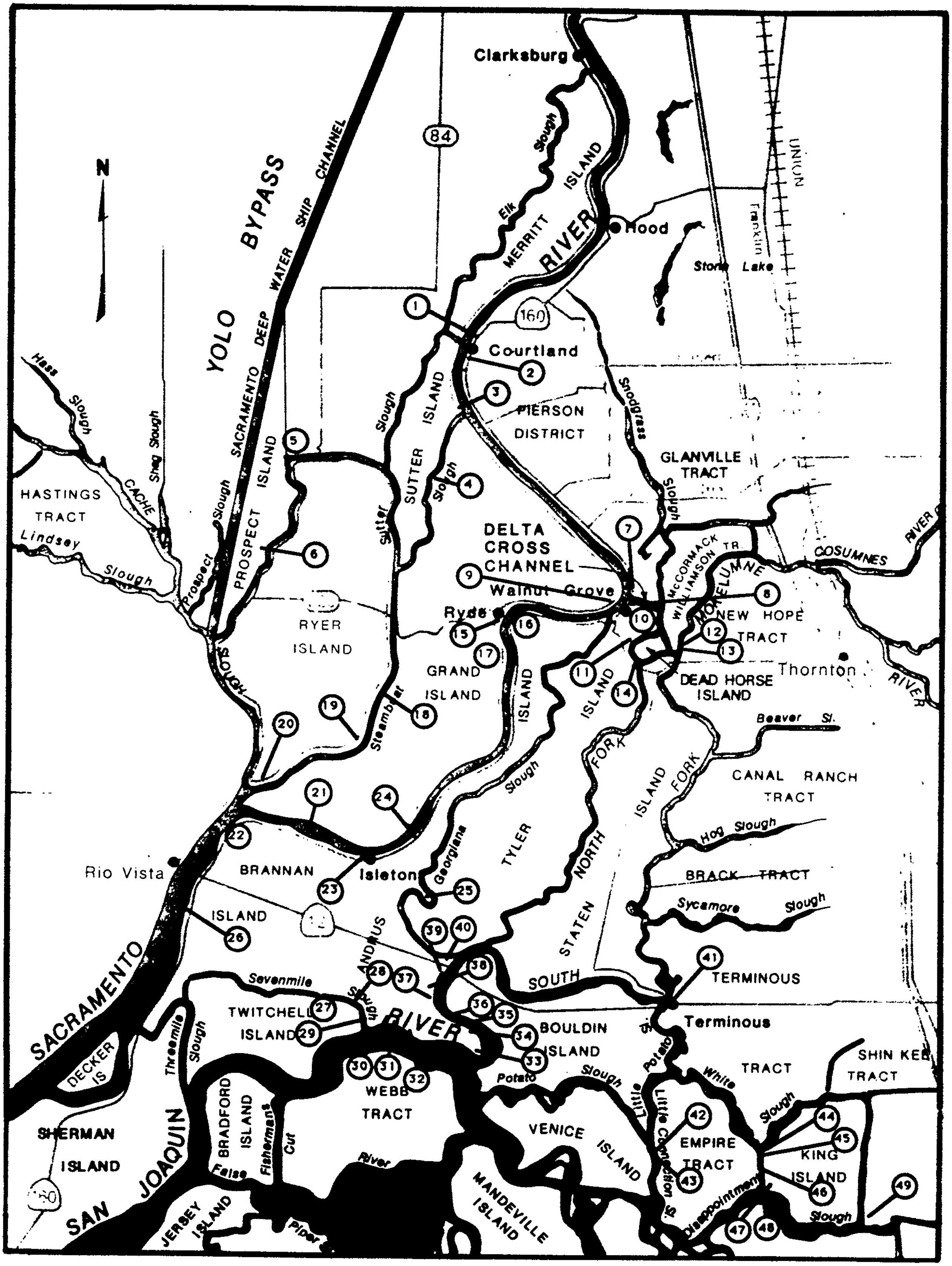

Figure 3.4–1. Commercial Recreation Facilities

There are numerous marinas and residential areas in the vicinity of the proposed project site. Most affected by the test closure of Georgiana Slough would be The Ox Bow Marina, on Snodgrass Slough near its junction with the Mokelumne River; Walnut Grove Marina, Delta Country Houseboats, New Hope Landing, Wimpy's Marina, and Giusti's on the Mokelumne River and Snodgrass Slough in the vicinity of Dead Horse Island, and The Boathouse, Landing 63, Deckhands, and Boon Dox on the Sacramento River in or near Walnut Grove. Figure 3.4-1 and Table 3.4-1 show the locations of marinas and other Delta recreation facilities.

Recreational boating in the Delta varies throughout the year, with the lowest activity in the winter and peak activity in the summer months. Inclement weather, cold water, tule fog, and shorter periods of daylight, as well as potentially high river flows are among the factors limiting winter and early spring boating. However, fishing for striped bass and salmon continues throughout these months.

Personal communications with marina operators and Delta boaters have indicated that activity is relatively low in February and March, but picks up sharply in April, particularly after two or more days of warm, sunny weather.

Some indications of boat traffic and recreational use on Georgiana Slough can be provided by use surveys and by operational statistics obtained from the two swing bridges on the slough and on nearby channels (Figure 3.4-2).

Several agencies were contacted to obtain use statistics. The State Department of Parks and Recreation has no jurisdiction on Georgiana Slough. The State Department of Boating and Waterways has no records on Georgiana Slough boat use.

Sacramento County Parks and Recreation monitors recreation activities in the area. The county staff indicate that there is mostly day use at Georgiana Slough and has estimated monthly usage, based on counts of cars parked along the slough.

Table 3.4-2. Day Use Along Georgiana Slough

1991	User Days	1992	User Days
January	387	January	309
February	525	February	218
March	279	March	348
April	398	April	481
May	728	May	465

The county staff indicate that during the February through April time frame the impact of barrier closure on recreation would be minimal.

The Sacramento County Sheriff's office was contacted. The Sheriff's office staff indicated that the boating and recreation impact would be low during February through April.

The U.S. Coast Guard routinely patrols the area. Coast Guard staff also indicate that during the February through April period the usage is very light. Staff indicate that the tule fog can persist through the month of April.

The Sacramento County Bridge Maintenance staff operate the two swing bridges across the slough and maintain records of openings and the number of boats passing with each opening. The count thus obtained is low, because an unknown fraction of the boating traffic consists of vessels small enough to pass beneath the unopened bridges. According to staff, typically one to five boats pass with each swing bridge opening. Nevertheless, this data provides a good indication of monthly variations in boat traffic throughout the year. Boat passage data for the Georgiana Slough Bridge, near the mouth of the slough are as follows:

Table 3.4–3. Georgiana Slough Bridge, Boats Passing During Bridge Openings

	1989 Open	1990 Open	1991 Open
Jan.	21	2	20
Feb.	23	20	49
March	32	30	20
April	98	131	68
May	181	164	185
June	175	129	120
July	281	225	295
Aug.	253	191	220
Sept.	243	124	177
Oct.	111	89	74
Nov.	26	21	22
Dec.	11	18	9

The numbers of boats passing during bridge openings for Tyler Island Bridge are as follows:

Table 3.4–4. Tyler Island Bridge, Boats Passing During Bridge Openings

	1989 Open	1990 Open	1991 Open
Jan.	34	50	12
Feb.	53	34	52
March	73	48	40
April	109	110	56
May	340	228	227
June	327	282	231
July	475	411	206
Aug.	380	305	313
Sept.	317	308	269
Oct.	179	162	141
Nov.	53	49	73
Dec.	33	14	28

Similar data has also been provided by the bridge operators for the Mokelumne River Bridge and for the Miller's Ferry Bridge. The Mokelumne River Bridge conveys Highway 12 traffic across the lower Mokelumne, below the confluence of the North Fork and South Fork. Caltrans has provided the following data:

Table 3.4–5. Mokelumne River Bridge, Openings and Vessels Passing

	1989		1990		1991	
	Open	Boats	Open	Boats	Open	Boats
Jan.	110	146	116	143	92	122
Feb.	124	174	146	178	176	290
March	145	216	---	---	154	274
April	286	526	270	449	264	482
May	459	911	416	802	345	859
June	473	805	445	926	435	766
July	740	1465	622	1320	539	1175
Aug.	635	1300	571	1107	594	1052
Sept.	588	1086	491	1098	467	967
Oct.	325	509	293	523	249	552
Nov.	192	284	205	280	184	265
Dec.	121	153	129	151	93	113

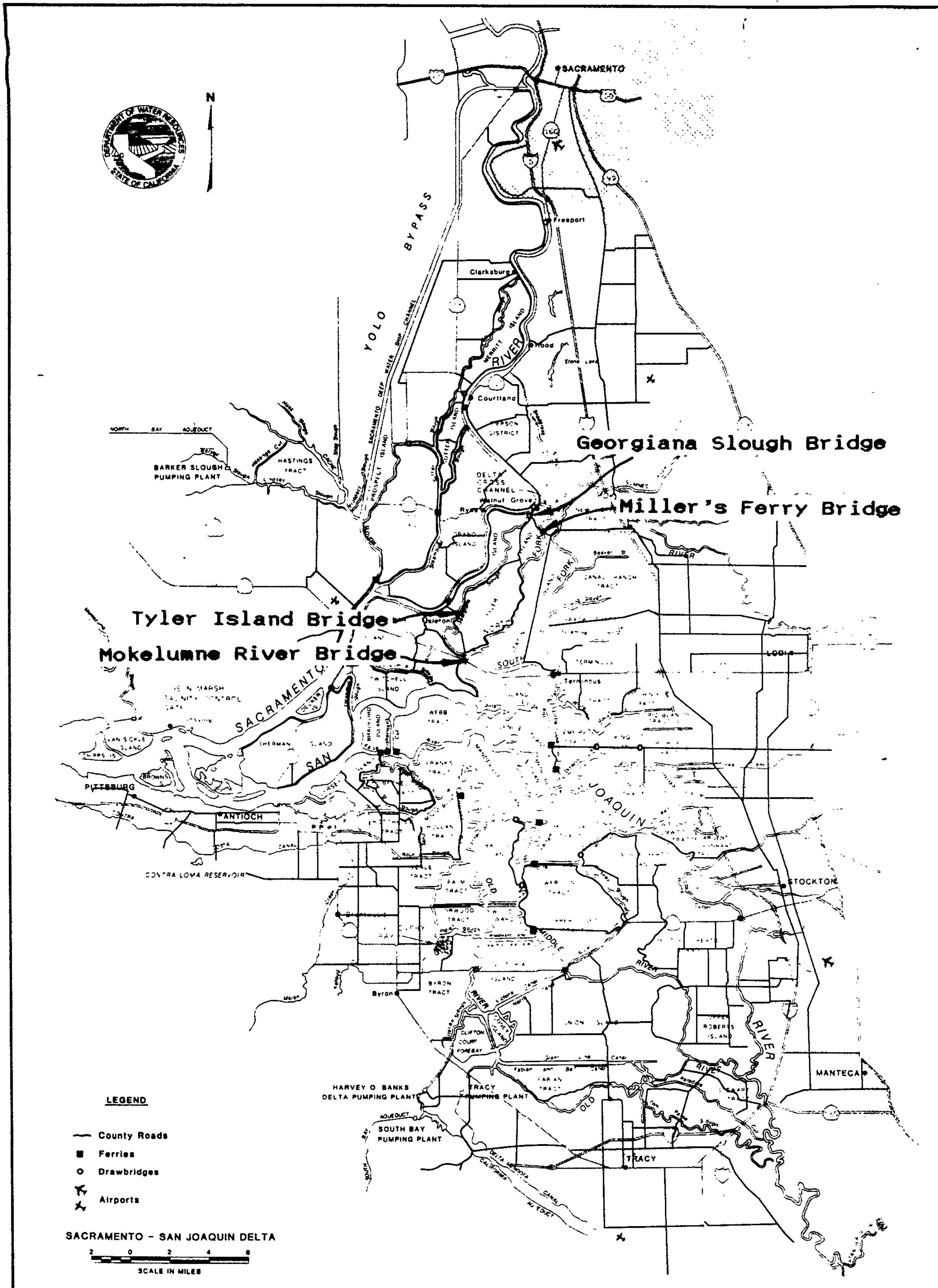

Figure 3.4–2. Swing Bridges Near Georgiana Slough

San Joaquin County operates the Miller's Ferry Bridge, which crosses the North Fork Mokelume at Walnut Grove, just below the confluence with Snodgrass Slough, and provided counts of bridge openings:

Table 3.4–6. Miller's Ferry Bridge, Openings

	1989 Open	1990 Open	1991 Open
Jan.	0	7	2
Feb.	4	2	4
March	11	9	2
April	8	14	11
May	134	217	138
June	259	197	140
July	420	372	298
Aug.	320	379	324
Sept.	356	272	268
Oct.	93	80	97
Nov.	11	3	5
Dec.	0	7	5

The records are in agreement with the assessments of boating activity levels by the agencies with jurisdiction over the Slough.

Environmental Consequences

Department staff met with operators of eleven marinas (Figure 3.4–1) in the north Delta area to discuss potential impacts and concerns related to the proposed project. The opinions of the operators are summarized below:

Tower Park Marina – According to the marina operator consulted, the proposed closure would have a definite impact on their business because Georgiana Slough is the main route to the Sacramento River.

Willow Berm – According to the marina operator consulted, the proposed closure would have a definite impact on their business. There is heavy use of the slough to get to the Sacramento River to fish for striped bass. He says the closure of Georgiana Slough will affect 30 of the 237 boats berthed at his facility. Fishing is the mainstay of his business.

Ox Bow Marina – According to the marina operator consulted, the proposed closure would have a definite impact on their business because the slough is the main route to the Sacramento River. The closure would definitely affect the fishing season.

Perry's Marina – According to the marina operator consulted, the proposed closure would have a definite impact on their business. The main reason is Georgiana Slough is major artery to the Sacramento River and it is a problem to go around Threemile slough because of the winds and distance. His main concerns are the boat traffic and the water levels. If the project significantly affects water levels, then it would cause problems for the boats berthed at his marina.

Walnut Grove Marina – According to the marina operator consulted, the proposed closure would have a definite impact on their business. The fishermen will have the main impact. Getting to the Sacramento River to fish would mean going a long distance. The manager contacted owners of boats berthed at the marina, and found there was substantial opposition to temporary closure of Georgiana Slough. The operator is sending DWR a letter requesting a public meeting and indicated that there may be support for protecting the salmon run.

Wimpy's Marina – According to the marina operator consulted, the proposed closure would have minimum impact because the Delta Cross Channel flood gates are closed during this time period. The operator expressed support for efforts to protect the salmon run.

New Hope Marina – The operator felt that the proposed closure would have minimum impact because boating is slow. There would be some impact on fishing. The operator expressed support for efforts to protect the salmon run.

Boathouse Marina – The operator felt that during February and March boating is slow, but suggested that the barrier be removed by the end of March because if April has two or more nice days boating increases dramatically.

B & W Marina – The operator felt that the proposed closure would have minimum impact because boating is slow during the proposed closure period. The operator expressed support for efforts to protect the salmon run.

Korth's Marina – The operator felt that the proposed closure would have minimum impact because fishermen launching from this marina generally go to Rio Vista to fish for striped bass. The operator expressed support for efforts to protect the salmon run.

Spindrift Marina – The operator felt that the proposed closure would have minimum impact because the proposed closure would occur during the slow season.

The operator expressed support for efforts to protect the salmon run.

In summary, discussions with regulatory management and law enforcement agencies, as well as marina operators and boaters, provide a preliminary indication that most of the proposed closure would occur during a time of year when boating activity is at a minimum. The closure could significantly affect boating activity if good weather occurs in conjunction with the Easter holiday in early April, 1993. Some fishing and cruising continue year–round and that activity would be impacted by the closure.

Mitigation

For the smaller boats (18 feet and under), some measures could mitigate for the impacts. A barge–mounted crane parked at the barrier will be used to lift boats directly over it, using a sling system to support the boats. Boat ramps are not recommended becasue of the proximity of potential archaeological resources and the need to minimize barrier volume to allow for rapid removal in the event of a threatened flood. As mentioned previously, periodic opening of the Delta Cross Channel gates at slack tide could also provide an alternative boat passage between the central Delta and the Sacramento River for the smaller vessels. If this option is viable, existing tide forecasts can be used to establish a tentative gate opening schedule.

For the large cruisers and sailboats which use Georgiana Slough, it is not practical to haul the boats out of the water, either by trailer or hoist, for passage past the proposed barrier. Shortening the closure period, so that the barrier is removed before mid–April, would probably greatly reduce impacts, as this is the period when cruising activity picks up rapidly.

3.5 Soils And Geology

Affected Environment

The Georgiana Slough Test Barrier Project site is located at the north end of Georgiana Slough between Andrus Island on the west and Tyler Island on the east. This area of the Delta is generally comprised of weak Holocene tidal and alluvial deposits, and underlying dense Pleistocene deposits.

Sediment deposition in the Delta occurs as three major rivers (Sacramento, San Joaquin, and Mokelumne) converge at sea level and either drop sediment loads in Delta channels or overflow levee banks onto Delta islands.

There is no geologic information directly available for the barrier site, however, detailed information was obtained from a bridge site approximately 600 feet south (downstream) of the proposed barrier location. Four soil bore holes were drilled and sampled at the bridge site in 1959 for Sacramento County. The bridge has a central axis upon which it pivots to allow marine traffic to pass. Of the four bore holes, two were drilled through the adjoining levees and two were drilled through the slough from a barge.

The soils were classified by visual inspection of the samples and continuous observation of the drill cutting returns.

Soils encountered at the bridge site can be distributed into four groups. The uppermost unit, comprised of intermixed alluvial and man–made levee deposits, consists of loose to dense silt, sand, and sand–gravel mixtures extending to about sea level in the vicinity of the levees. From sea level to approximately 37 feet below sea level, the soils consist of Holocene tidal deposits, very loose to medium dense silt, sand and silty sand, locally abundant peat and other organic material. From 37 feet below sea level to an irregular horizon varying from 43 to 54 feet below sea level, a unit consisting of Holocene non–tidal (alluvial) deposits, loose to medium dense silt, sandy silt, and sandy clay was encountered. No organic material was encountered below 37 feet below sea level. Underlying the entire site from 54 to at least 82 feet below sea level, a series of Pleistocene non–tidal (alluvial) sediments consisting of medium dense to dense sand and silt, and very stiff to hard clayey silt occurs.

The geologic conditions at the rock barrier site are expected to be similar to those at the bridge site. To confirm this expectation, DWR will be drilling one exploratory hole on the west levee at the proposed barrier site. This hole will be deep enough to encounter all of the materials described above.

Environmental Consequences and Mitigation

No impacts are anticipated because the proposed rock, gravel, and sand barrier will not affect ground water levels, subsidence, or levees. Upon completion of the test most of the barrier material will be removed. It is anticipated that if the barrier erodes in the course of a flood event, much of the barrier material will be dispersed downstream. This material is similar to that which historically has been placed on levee slopes and stream banks to control erosion. Limited local increase in rock, gravel, and sand on the slough bottom is not expected to have an adverse impact on benthic life or on the stability of the channel.

3.6 Water Quality

Affected Environment

Over one hundred years ago Californians proceeded to transform marsh and swamp land into one of the most productive agricultural communities in California. However, its importance in present day society goes beyond farming. Approximately 55 percent of the state's water flows in channels that are tributary to the Sacramento–San Joaquin Delta. There are 1,800 water diversions in the Delta, which pump or siphon water from Delta channels to meet these beneficial uses.

The two largest diversion projects are the Central Valley Project and the State Water Project. Combined, they lift nearly 7 million acre–feet of water to meet a portion of the needs of two–thirds of the state's population and irrigate 4.5 million acres of agricultural land.

The Bay–Delta estuary water quality and tidal hydraulics are complex. When Delta outflows meet the higher salinities of the bay and ocean, salinity gradients result from the mixing of fresh water and ocean water. The magnitude and extent of these gradients depend primarily on the magnitude of Delta outflows and ocean tides. As outflows increase, the mixing zone tends to shift seaward, increasing the salinity stratification and compressing the mixing zone.

Other factors affecting the estuary water quality and hydraulics include channel geometry, wind, barometric pressure, local and project diversions, agricultural drainage, pollutant discharges, and ambient temperature.

Water conditions in the north Delta are primarily influenced by inflows from the Sacramento River, the Mokelumne River, Dry Creek, the Cosumnes River, and intrusion of brackish water from the west Delta.

Salt concentrations are lowest during wet water years with high–flow conditions, and are highest during critically dry years. Typically, salinity is highest in July and August, regardless of the type of year. In below–normal years, salinity may increase dramatically as early as May.

In the past 30 years, the State Water Resources Control Board (SWRCB) has been involved in issuing water right permits and defining water quality and flow standards for the Delta. In developing the standards, the Board considered various beneficial uses of Delta waters. The standards set by decisions handed down by the SWRCB include: 1) municipal and industrial which are based on health factors; 2) agricultural which are based on the salt sensitivity of crops; and 3) fish and wildlife which are based on salinity and flow criteria designed to improve conditions for resident and migratory fish. These standards are discussed in detail in the latest decision from the Board, D–1485. Extensive discussions of these issues have continued in Board hearings in 1987 and in interim standards hearings in 1992.

Georgiana Slough provides an important hydraulic connection between the Sacramento River and the central Delta. During periods of high flows, the channel shunts excess flood flows to the San Joaquin River. During periods of low flow, high quality water flows into meandering waterways of the central Delta.

Environmental Consequences

Preliminary studies have been conducted to analyze the effects of blocking Georgiana Slough on Delta water quality and on SWP operations.

The hydraulic impacts of closing Georgiana Slough and the Delta Cross Channel gates were evaluated with total Sacramento River flows (at Freeport) at 10,800 cfs and at 20,800 cfs. The San Joaquin River flow was assumed to be 1,200 cfs; other local stream flows, including the Mokelumne, were assumed to have no inflow (these local streams contribute a very samll fraction of total Delta inflow during a normal to dry summer). Two different levels of export were assumed, but do not affect the stage and flow in Georgiana Slough because the lower San Joaquin River, with its very large channel open to the Bay, almost entirely compensates for variations in export rates. Figure 3.6–1 shows four key locations for which water surface elevations, flows, and velocities were evaluated.

Water Surface Elevations (Stages)

Figure 3.6–2 shows the water surface elevation (stage) over a full tidal cycle in four locations when the Sacramento River is running at 10,800 cfs. It shows stages at the Sacramento River above Georgiana Slough, Georgiana Slough just downstream from the proposed barrier location, Georgiana Slough about 7.5 miles downstream from its mouth, and the Mokelumne River near its junction with the San Joaquin. The solid lines show the stages without the barrier in place; the dashed lines show the stages after the barrier is in place.

Figure 3.6–2 shows that a barrier in Georgiana Slough would increase the stage of the Sacramento River by about one–half foot, and lowers the stage downstream of the barrier in Georgiana Slough by about the same amount. It has negligible effect on stages in the Lower Mokelumne River.

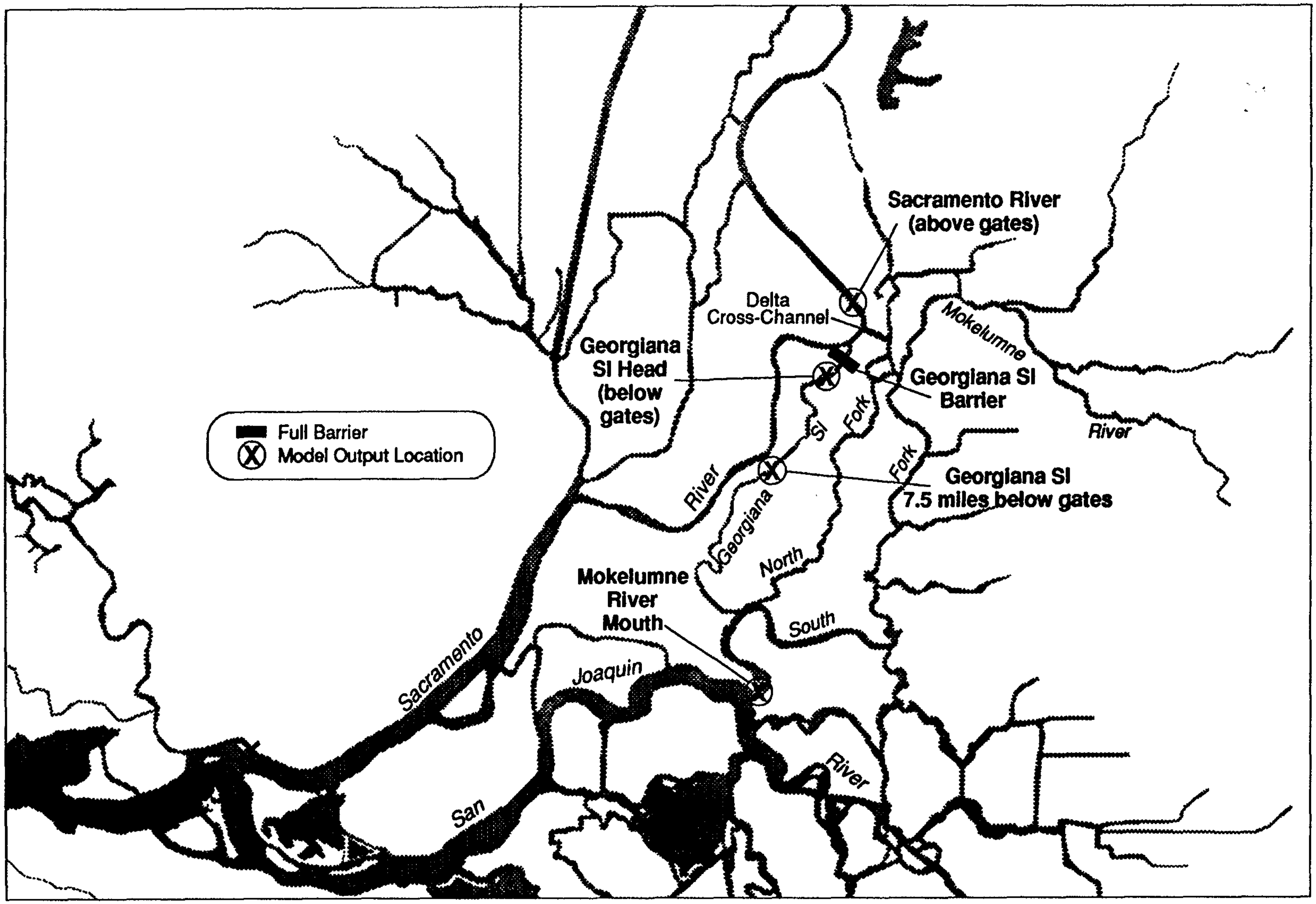

Figure 3.6–1. Locations Where Stage, Flow, and Velocity Were Evaluated

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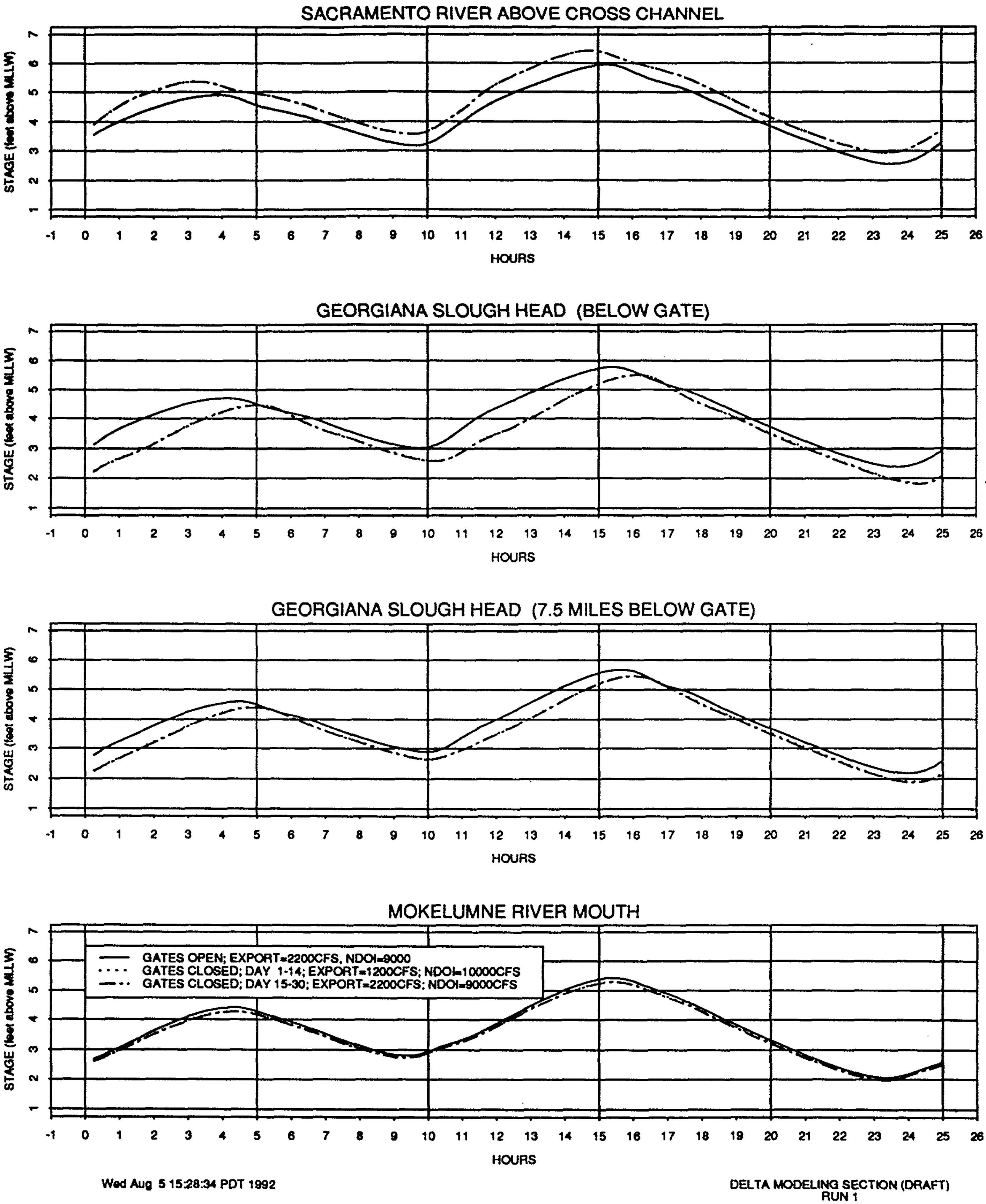

Figure 3.6–2. Tidal Cycle Stage: Sacramento Flow Equals 10,800 CFS

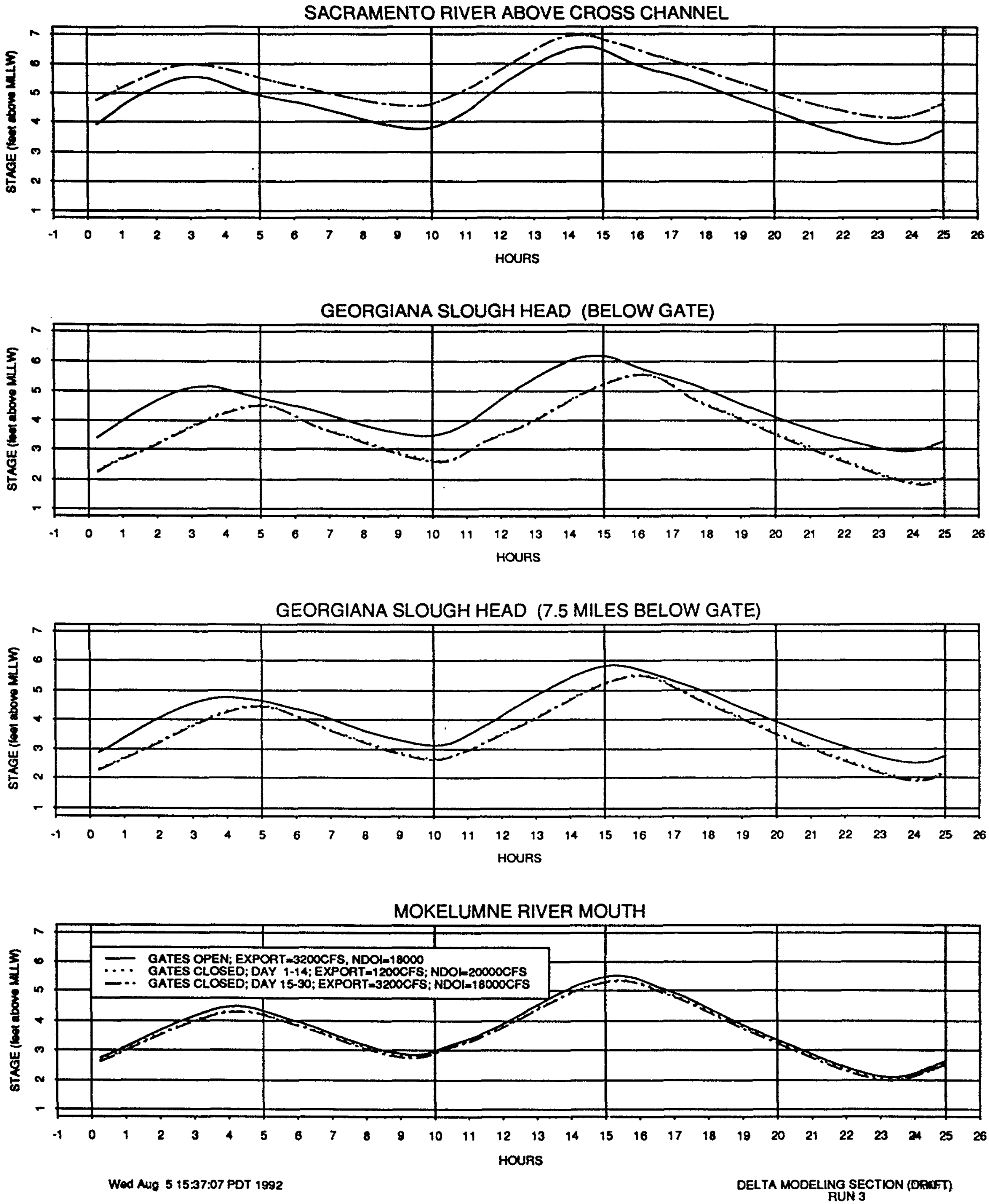

Figure 3.6–3. Tidal Cycle Stage: Sacramento Flow Equals 20,800 CFS

Figure 3.6–3 is similar to Figure 3.6–2, except that Sacramento River flows have been increased to 20,800 cfs. The increased flow magnifies the effect of the barrier, particularly at low tide, raising the Sacramento River stage by nearly a foot, with a corresponding decrease below the barrier in Georgiana Slough. Even with this flow in the Sacramento River the barrier would have no significant effect on stages in the lower Mokelumne River.

Flows

Figure 3.6–4 and 3.6–5 show flows for the same conditions and locations as Figures 3.6–2 and 3.6–3, respectively. As expected, both figures show that flow at the mouth of Georgiana Slough is eliminated just downstream of the barrier.

There are some flows about 7.5 miles downstream of the barrier due to tidal pumping from the San Joaquin River. The tidal phase has been essentially reversed, the magnitude of flows over the tidal cycle has been reduced, and there is no net flow.

Figures 3.6–4 and 3.6–5 show that closing Georgiana Slough has a significant effect on tidal flow in the Lower Mokelumne River. Since there is no flow from the Sacramento River, it makes little difference whether the Sacramento River is running at 10,800 cfs or 20,800; the lower Mokelumne River flow is almost the same for both cases. With the barrier in place, flows vary from about 14,500 cfs downstream on the ebbing tide and a similar flow upstream. Normally the Sacramento River flow entering the Mokelumne River via Georgiana Slough and the Delta Cross Channel decreases the upstream tidal flow but has a relatively small effect upon the outflow.

Velocities

Figures 3.6–6 and 3.6–7 show the effects of closing Georgiana Slough on water velocities at the four selected locations. As expected, velocities within Georgiana Slough are reduced to zero at the barrier, and much reduced within the rest of the slough. In both the Sacramento River upstream of Georgiana Slough and in the Molelumne River downsteam of the slough there is an increase in upstream flow velocity at low tide.

This increased velocity at low tide may be significant in the Mokelumne River channel, where levee erosion on the right bank downstream from the Highway 12 bridge is an ongoing concern. The duration of exposure to maximum water velocity is increased.

Water Quality

The impact of barrier installation upon water quality in Georgiana Slough is unknown. This is an important concern, because, according to local residents, the slough serves as a source of drinking water for some residences and resorts located on its banks in addition to its use by fish, wildlife, and farmers. As described in the paragraphs above, tidal fluctuations will continue in the slough, with a reduced magnitude, but there will be little flushing action, particularly in the northern portion of the slough. The timing, volume, and chemical makeup of local discharges which might occur in the February 1 through April 30 period are unknown. Local discharges into the slough, in the absence of normal flushing action, could potentially impact water quality.

The impact of Georgiana Slough closure on the rest of the Delta has not been fully analyzed. However, modeling does suggest that under low flow conditions there will be higher than normal salinities in most areas of the interior Delta.

Mitigation

In order to mitigate for potential local water quality concerns, frequent, regular monitoring will be undertaken as part of the test barrier project. If odor, turbidity, bacterial, or chemical thresholds established by the SWRCB, the Regional Water Quality Control Board, Central Valley Region, and the State Department of Health Services are exceeded, steps will be taken to eliminate the problem. Two gated culverts, one 48 inches and the other 72 inches in diameter, will be embedded in the barrier, and could be opened to allow some flushing action if necessary. Another option is to breach the barrier or provide alternative domestic water supplies such as commercially available bottled water.

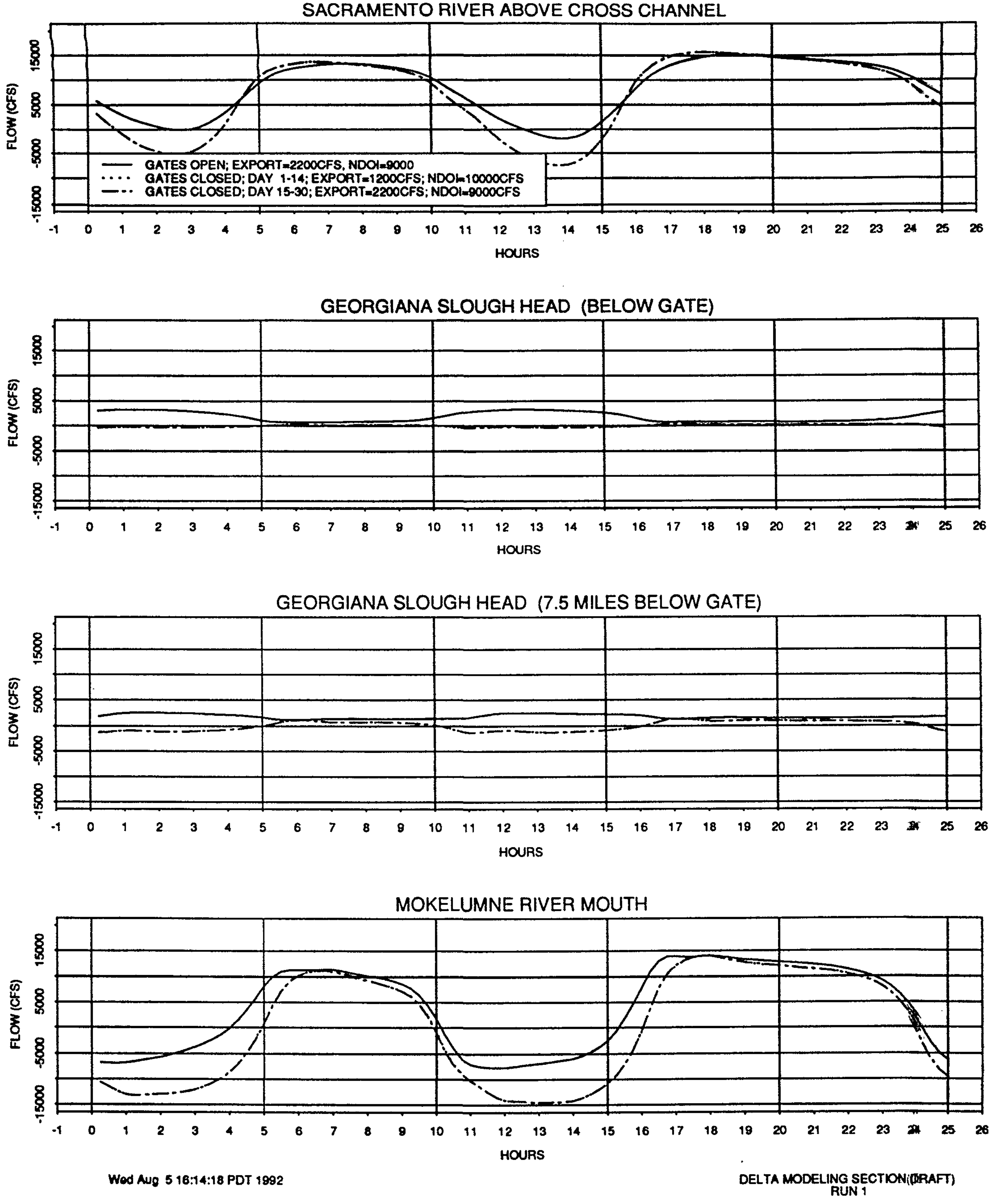

Figure 3.6–4. Tidal Cycle Flow: Sacramento Flow Equals 10,800 CFS

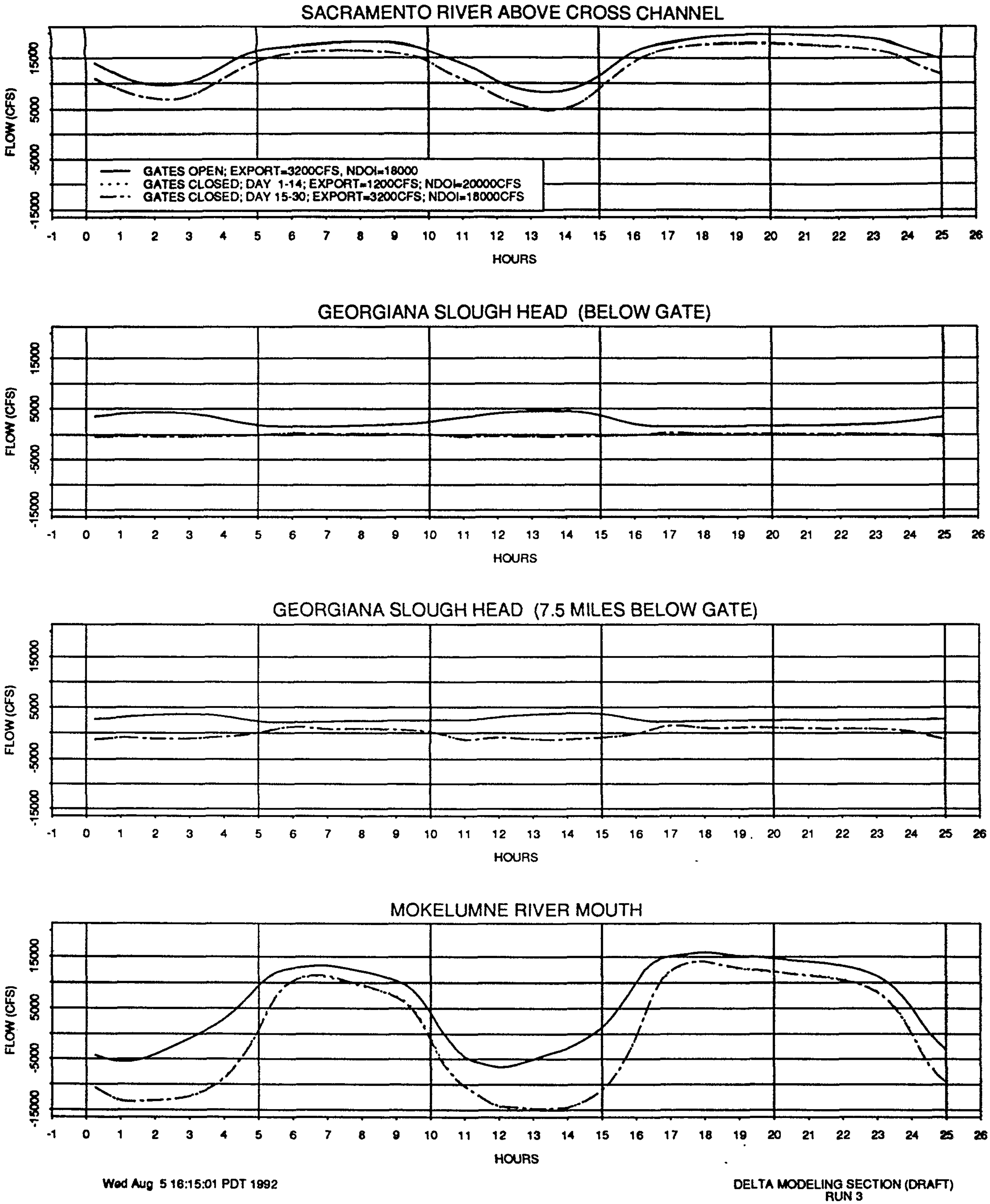

Figure 3.6–5. Tidal Cycle Flow: Sacramento Flow Eequals 20,800 CFS

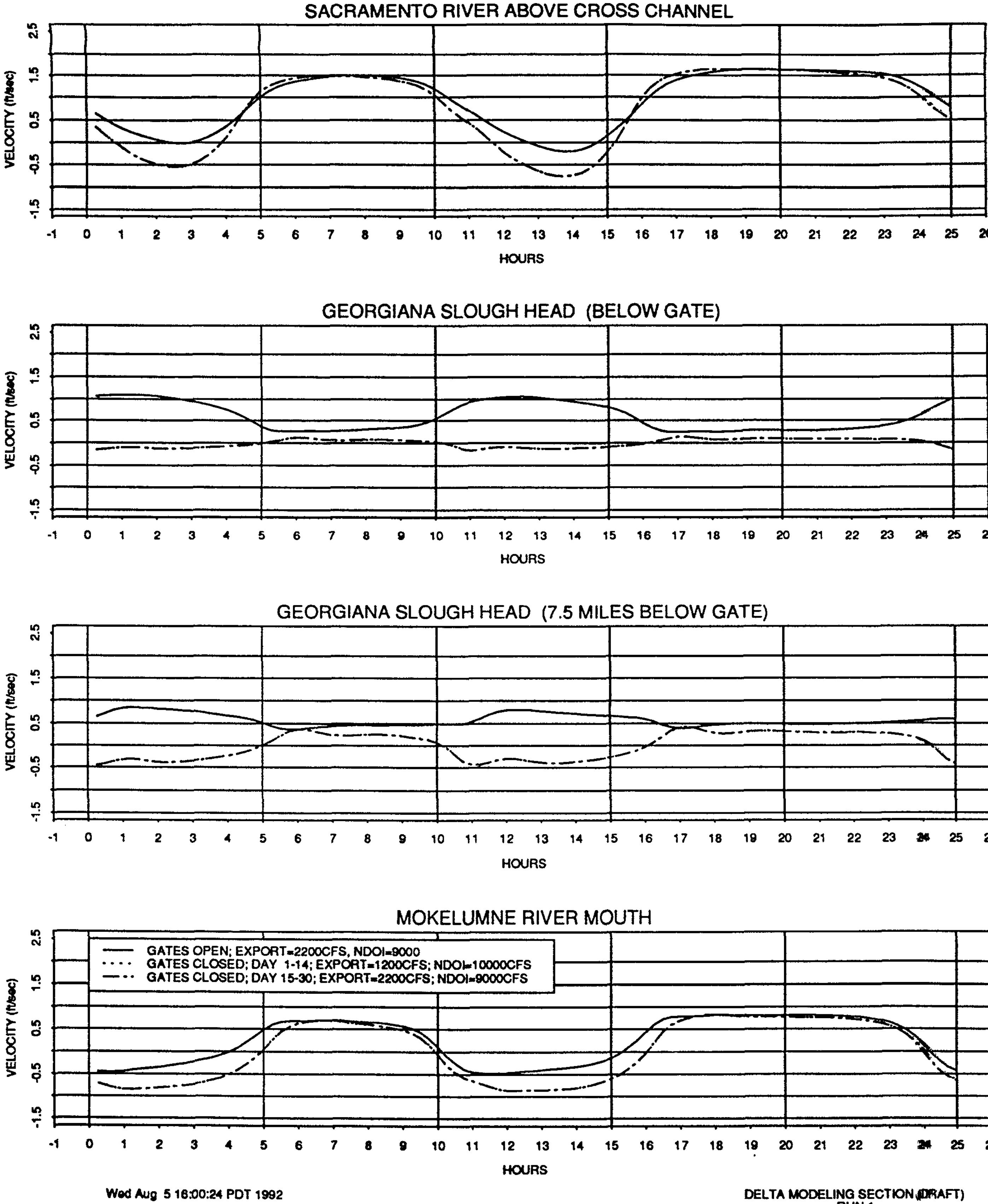

Figure 3.6-6. Tidal Cycle Velocity: Sacramento Flow Equals 10,800 CFS

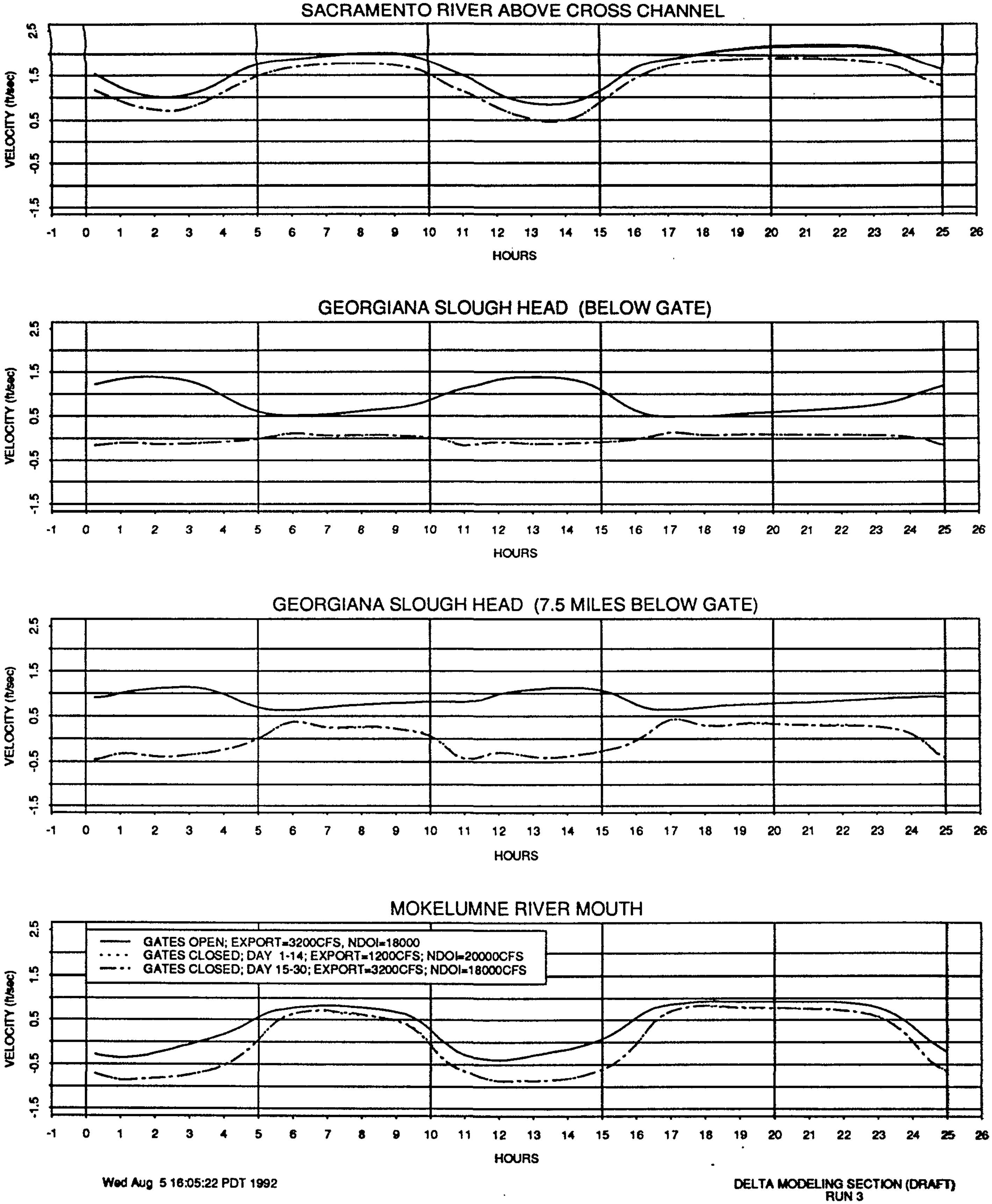

Figure 3.6–7. Tidal Cycle Velocity: Sacramento flow Equals 20,800 CFS

Regional Delta water quality changes which may occur can be mitigated by two potential measures: SWP and CVP export operations will continue to be constrained by existing contracts, agreements, and water rights decisions. Operations will be adjusted to continue compliance with these constraints. If operational measures are not sufficient, the culverts in the barrier can be opened. If this is not sufficient, the barrier can be breached.

3.7 Flood Hydrology

Affected Environment

Georgiana Slough is an integral part of the Sacramento River Flood Control Project, conveying about 20 percent of the total Sacramento River flows entering the Delta during a major flood.

The Sacramento River Flood Control Project is a complex system of reinforced levees, overflow weirs, bypass channels and channel enlargements extending from Shasta Dam in the north to southeast of Rio Vista in Sacramento–San Joaquin Delta. This system is an extension of the integrated flood control plan designed by the state engineer William Hammond Hall in 1880. In 1911, the Reclamation Board was created to see that this plan was carried out. Federal authority for the Sacramento River Flood Control Project came as a result of the 1917 Flood Control Act by the U.S. Congress. It took until 1960 to complete the project with the help of local, State, and federal funding.

As the Sacramento River flows southward from Shasta Dam near Redding, natural overflow areas and two fixed weirs, Moulton Weir and Colusa Weir, allow flood water to escape from the river into the Butte Basin. This basin is an undeveloped natural flow area, with a carrying capacity of 150,000 cfs at the southern end, before flowing into the upstream end of the Sutter Bypass (Figure 3.7–1).

At Tisdale Weir, additional water can be diverted from the Sacramento River into the Sutter Bypass, joining the drainage water from the Feather River Basin, Honcut Creek, Yuba River, and the Bear River system. Design carrying capacity of the Sutter Bypass at its southern end is 380,000 cfs.

The Sutter Bypass and the Sacramento River join just above Fremont Weir, near Verona. This weir divides the joint flow of the river–bypass system in a way that limits the design flow in the Sacramento River to less than a quarter of the total discharge and allows the excess water to move directly into the upstream end of the Yolo Bypass.

The Sacramento Weir, the only weir in the system with control gates, can discharge up to 112,000 cfs into the Yolo Bypass. There is a strong correlation between the outflow from Folsom Lake and water surface elevations at I Street Bridge in Sacramento, which in turn affects the operation of the Sacramento Weir. Although constructed upstream of the American River confluence, the Sacramento Weir can divert excess American River flows into the Yolo Bypass. The Yolo Bypass has a design hydraulic capacity of 500,000 cfs, while the design flow in the Sacramento River is limited to 110,000 cfs as it enters the Sacramento–San Joaquin Delta.

From the I Street Bridge in Sacramento, the Sacramento River enters the northern region of the Sacramento–San Joaquin Delta.

A substantial portion of the Sacramento River flow is diverted and carried through Steamboat Slough and Sutter Slough. Downstream from Walnut Grove, Georgiana Slough is designed to carry 20,600 cfs, or 36 percent of the flood flow remaining in the Sacramento River at Walnut Grove, while the Sacramento River channel is designed to convey 35,900 cfs, or 64 percent.

Figures 3.7–3 through 3.7–5 provide stage–frequency data for the Sacramento River at Sacramento and Georgiana Slough. Figure 3.7–3 shows stages for the months of February, March and April (the proposed period of closure), for the years 1983 through 1991. Stages have only rarely exceeded 10 feet in this period. However, the stage–frequency plot for the same location shows that a ten foot elevation is exceeded forty years out of a hundred. A stage of 11 feet is exceeded thirteen years out of a hundred.

In addition to the Sacramento River Basin, the north Delta region drains flood waters from more than 2,000 square miles of watershed east of the Delta through the lower Mokelumne River system, and eventually into the San Joaquin River (Figure 3.7–2). The Morrison Creek Stream Group, the Cosumnes River Basin, the Dry Creek Basin, and the Mokelumne River Basin are not a part of the Sacramento River Flood Control Project. Except for Camanche Reservoir on the Mokelumne River, these basins lack significant flood control storage facilities and other flood water regulation systems.

The constricted channels of the Mokelumne River system, with generally inadequate levees provide the only

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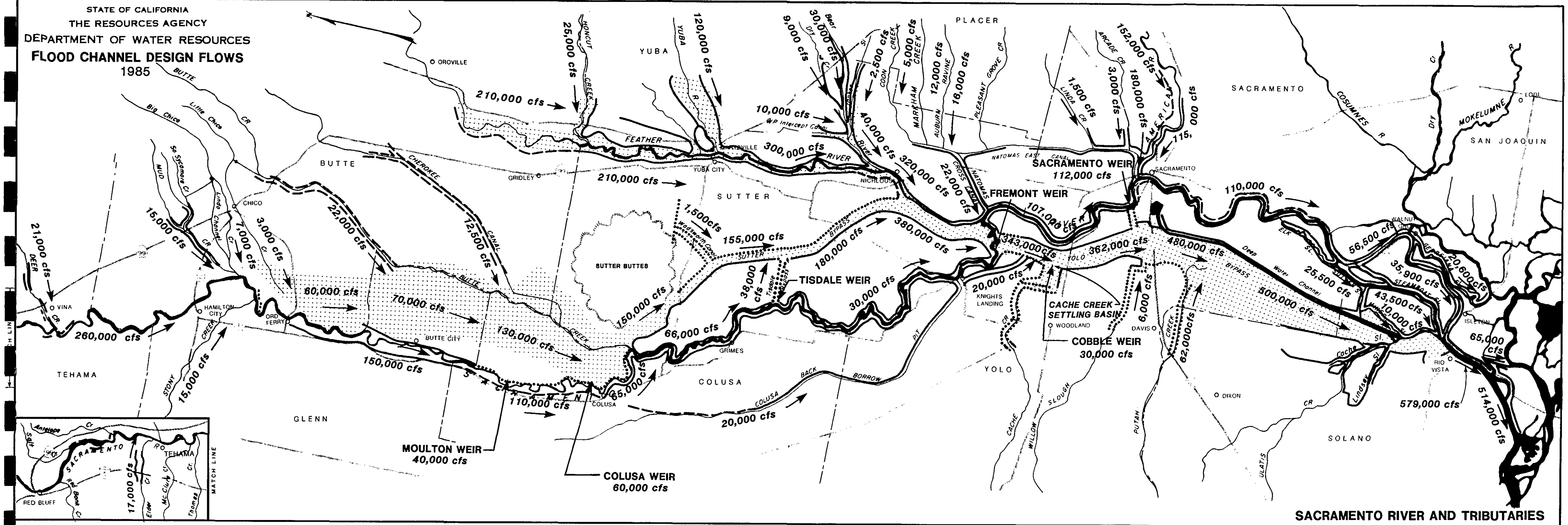
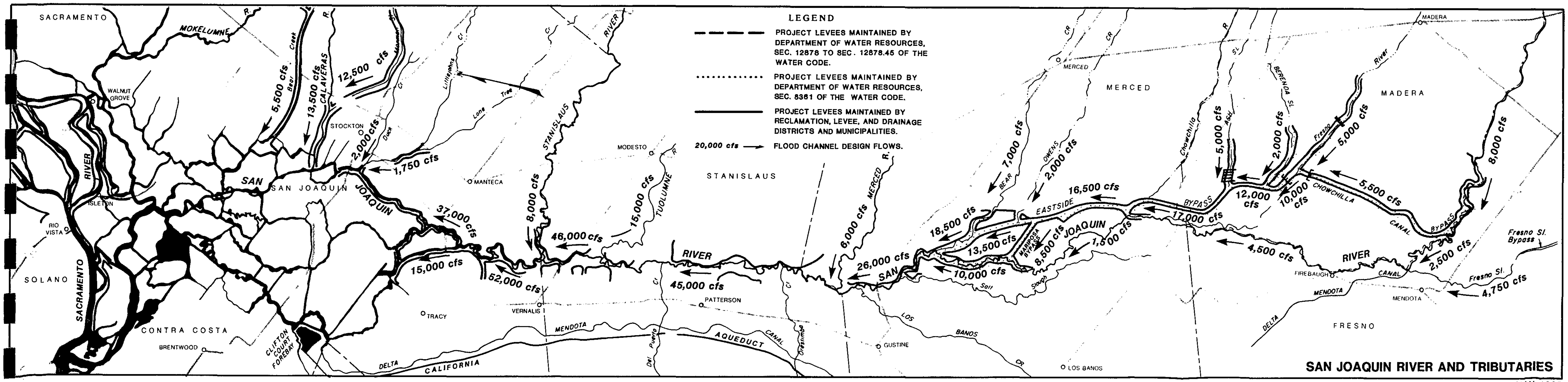
Figure 3.7-1





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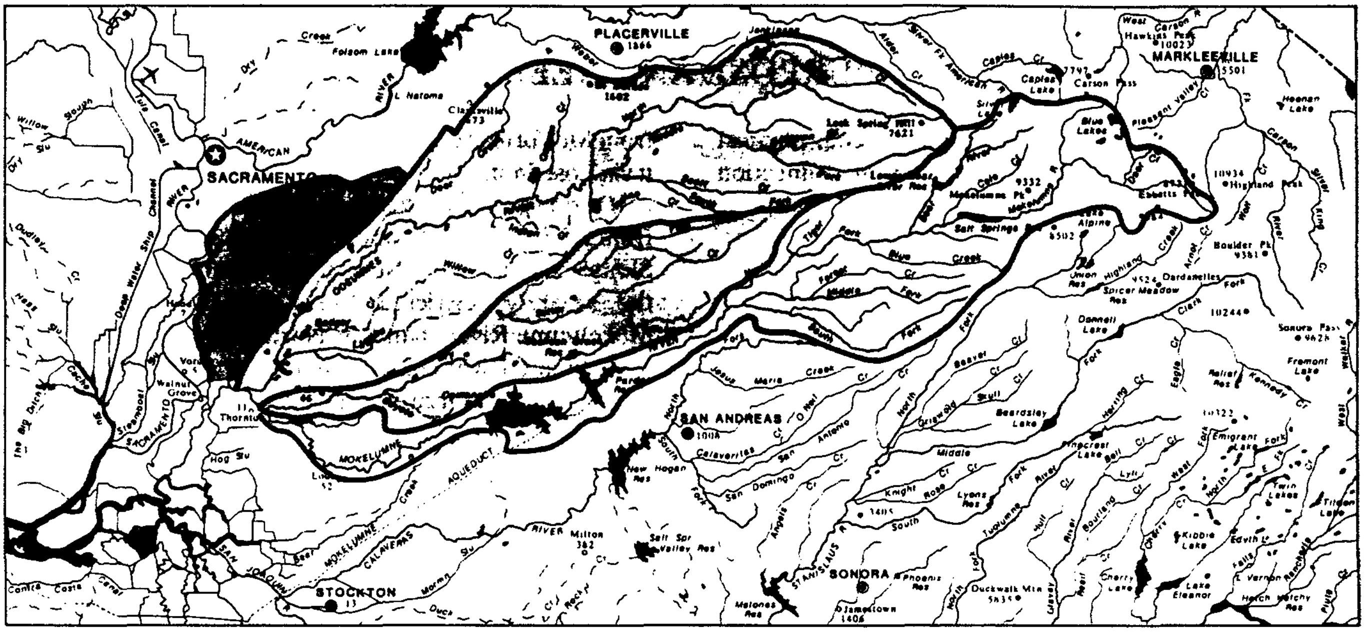

LEGEND
Morrison Creek Drainage Basin
Cosumnes River Drainage Basin
Dry Creek Drainage Basin
Mokelumne River Drainage Basin

Figure 3.7–2. Mokelumne River Watershed, Including Tributaries

pathway for draining the flood waters of these basins. The Delta Cross Channel, north of Walnut Grove, is closed during high flow conditions to prevent Sacramento River flood water from contributing to the flood problems in the Mokelumne River system. The Delta Cross Channel flood control operation criterion requires that both gates be closed at discharges above 25,000 cfs in Sacramento River, as measured at the Freeport Gage.

Environmental Consequences

A key question related to the operation of the Georgiana Slough Test Barrier Project is whether the flood warning lead time would be adequate for removing the barrier to reduce flood hazards on the lower Sacramento River. To resolve this question it is necessary to develop adequately conservative flood warning criteria, coordinated with mechanisms for removing the barrier as an obstruction to flood flow. This section describes and discusses recommended flood warning criteria for removing the barrier based on historical floods and an estimate of the potential lead time.

One criterion for removing the proposed Georgiana Slough barrier could be when the Sacramento River at I Street is forecast to reach 27 feet. This is 0.5 feet below the stage for opening the gates of the Sacramento Weir and corresponds to a flow of about 94,000 cfs. This stage has been exceeded in 13 of the years since 1955 when Folsom Dam began operation. Multiple flood events above this stage have occurred in several years. Since flood forecasts are often rounded to the nearest foot, the 27 foot stage is likely to be predicted slightly more often; at most, in 40 percent of years would such a forecast be expected. Overflow depths at Fremont Weir for events of this magnitude were generally from two to four feet. This stage also appears to correspond to a stage of 11.5 feet at Walnut Grove (depending on Yolo Bypass flows), which is 3 feet below project flood stage and is a reasonable stage threshold for removing the barrier.

Estimated flood travel time from I Street to Walnut Grove is about 10 hours based on past floods. Flood bulletins issued jointly by the California–Nevada River Forecast Center and DWR provide an additional 12 to 36 hours of warning time at I Street.

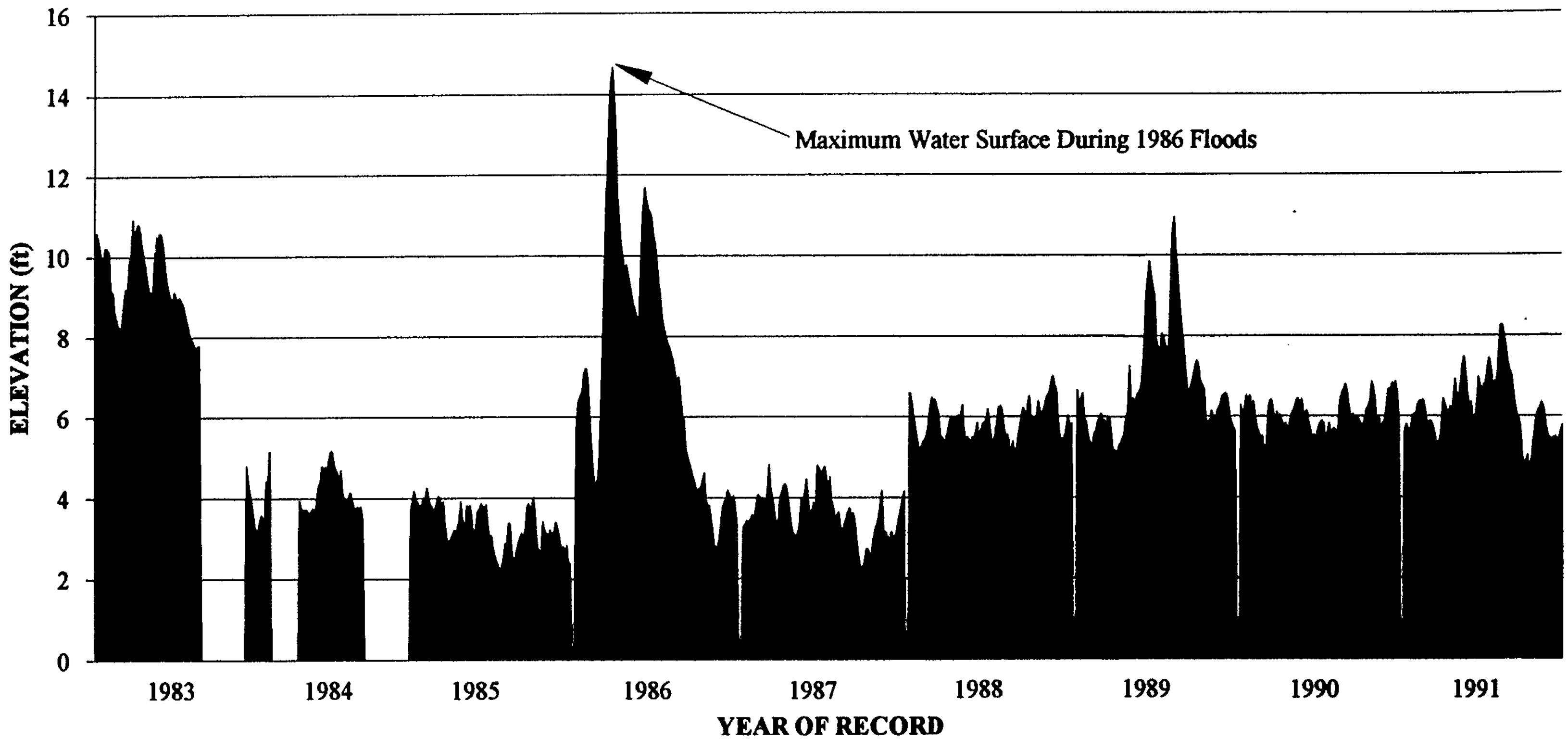

Figure 3.7–3. Georgiana Slough, High Water Elevations in February, March, and April

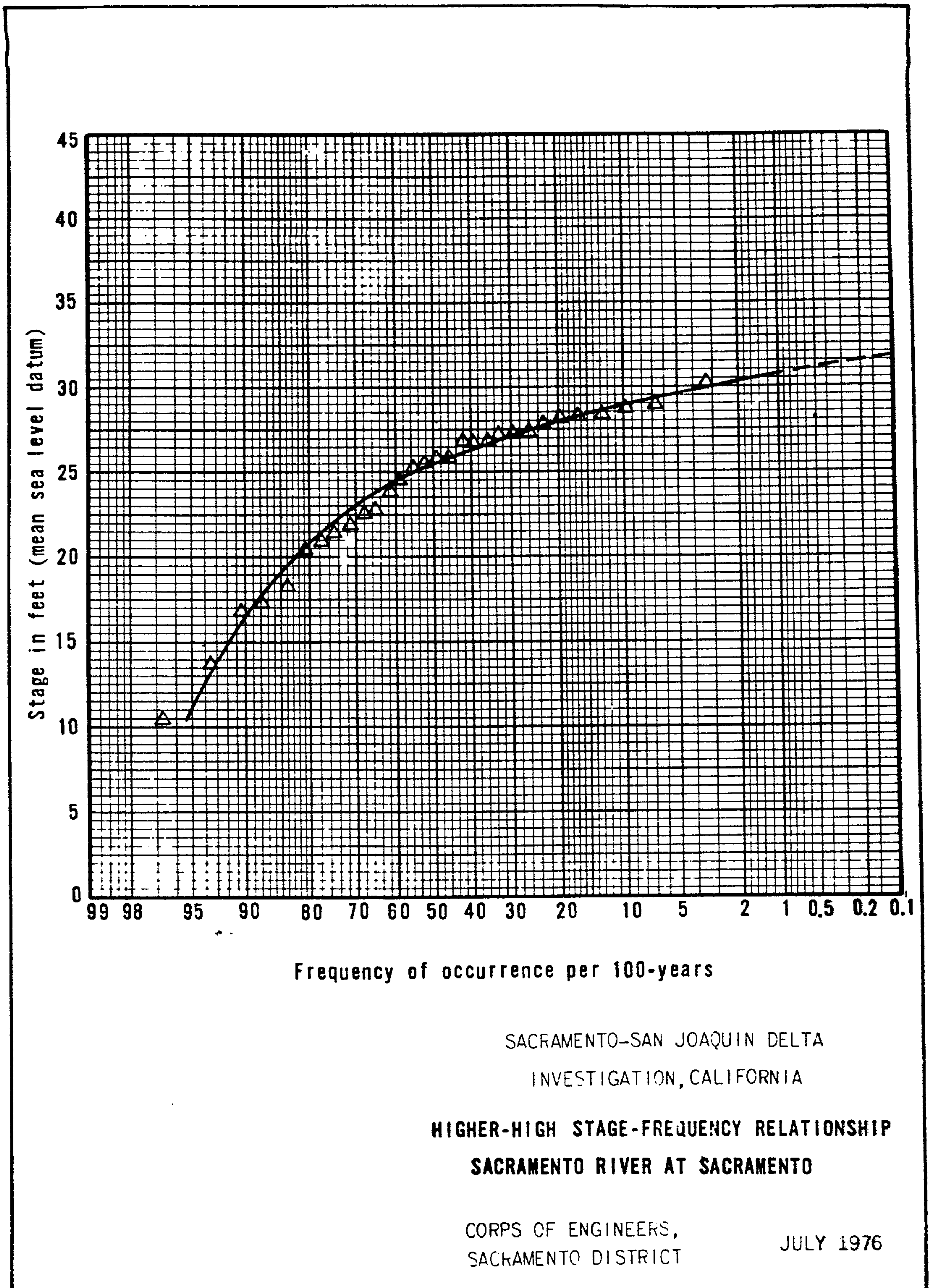

Figure 3.7–4. Higher–High Stage–Frequency Relationship Sacramento River at Sacramento

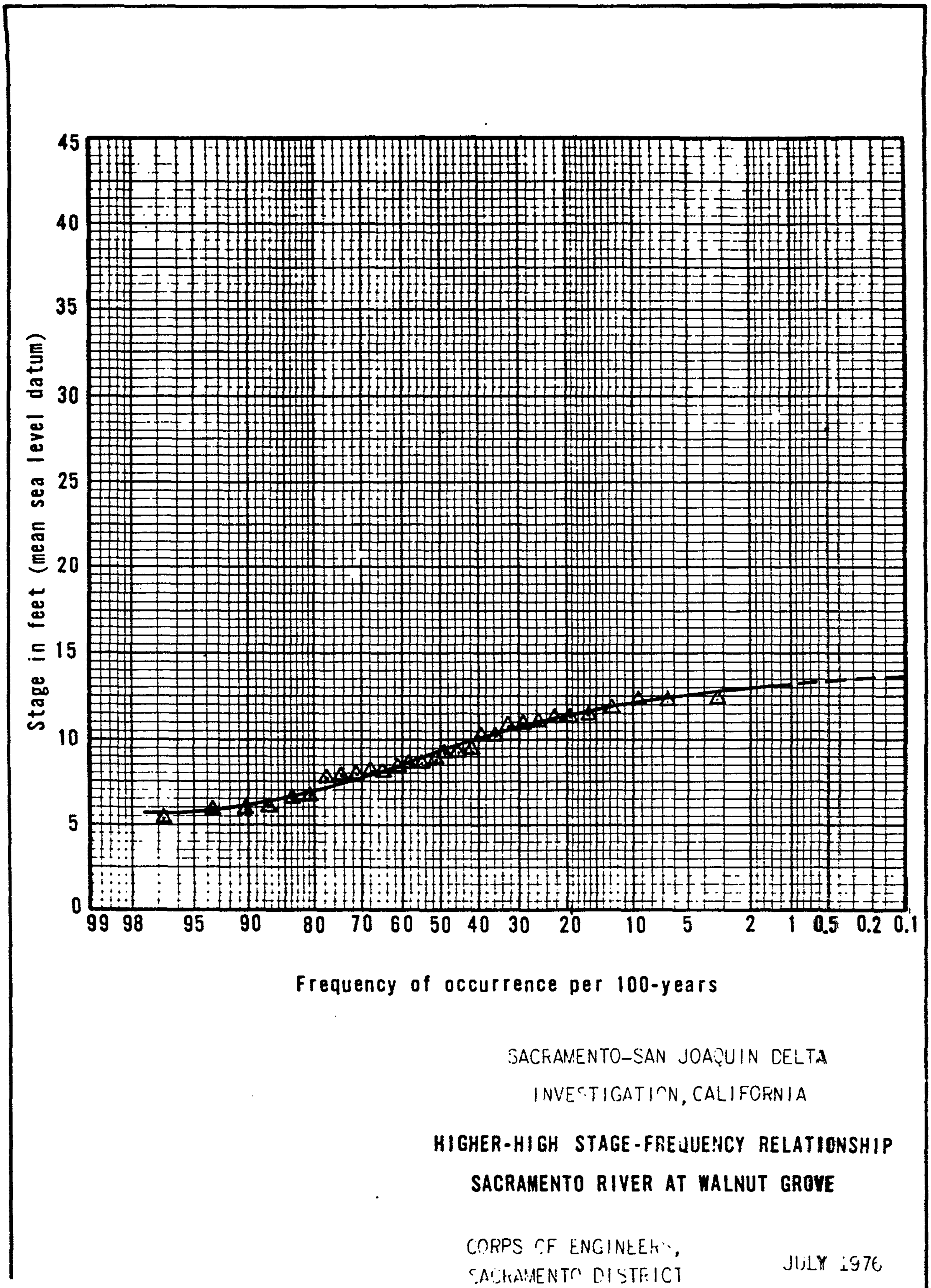

Figure 3.7–5. Higher–High Stage–Frequency Relationship Sacramento River at Walnut Grove

A second criterion could be Folsom flood control releases equal to or exceeding 40,000 cfs. These releases have coincided with I Street stages of 27 feet or greater in the past. This is about a 3-year event based on the Corps' regulated peak flow frequency curve for the American River at Fair Oaks. Lead time could be increased by extending the precipitation forecasts used in the headwater forecasting model for inflow to Folsom beyond 12 hours. Modest skill exists in precipitation forecasts out to 24 and perhaps 48 hours, although uncertainty in inflow projections would increase.

A third criterion for removal of the barrier could be when projected flows in the Sacramento River would exceed channel capacity downstream from Georgiana Slough. At design capacity the Sacramento River downstream from Sacramento carries 110,000 cfs, which splits into four channels:

- Steamboat Slough Carries 28,000 cfs,
- Sutter Slough carries 25,500 cfs,
- Georgiana Slough carries 20, 600 cfs, and
- The Sacramento River below Georgiana Slough carries 35,900 cfs. If it is assumed that the flow which normally passes through Georgiana Slough is evenly distributed between the three remaining channels, the threshold for removal of the barrier would be the forecast stage in Sacramento at I Street corresponding to 89,400 cfs (i.e. 110,000 cfs – 20,600).

However, the effect of Georgiana Slough closure would be greatest close to the mouth of the slough; therefore a somewhat higher proportion of flow in the remaining three channels would take the lower Sacramento River, rather than Sutter or Steamboat. Taking this into account reduces the threshold flow for the Sacramento River at I street from 89,400 cfs to about 86,000 cfs, corresponding to a stage of 25 feet. This is the current warning stage for the Sacramento River at I Street. This criterion is the most conservative of the three considered.

The amount of actual lead time available for removing the barrier will depend on the relative contributions of flood flows from the upper Sacramento, Feather, Yuba, and American watersheds. Storms that produce high flows on the upper Sacramento River allow more lead time than those that are more intense in the southern end of the Sacramento Valley. High stages in the vicinity of the barrier may follow minor rises on the upper Sacramento if Folsom Dam is making large flood control releases. Given the 18 hour travel time from Folsom Dam to the Georgiana Slough barrier, rapidly developing storms on the American River would produce conditions with the shortest response time.

A review of operations since Folsom Dam was constructed show two events with particularly short lead times. In the February 1986 flood both the suggested I Street and Folsom release criteria would have triggered a decision to begin removal of the proposed barrier on February 16. The lower Sacramento River flood bulletin issued at 6 p.m. on the 16th called for a rise to 27.5 feet the following morning. The stage reached 27 feet by 2 a.m. that morning. The Folsom release increased from 20,000 cfs at 4 a.m. to 50,000 cfs by 10 p.m. on the 16th. The decision to increase releases to 50,000 was made early that afternoon, at a time when inflows were fluctuating between 50,000 and 60,000 cfs from the first storm wave. During the 36 hour period beginning at noon on the 16th, the stage at Walnut Grove rose from 8.9 feet to 11.5 feet. The peak stage of 14.7 feet at Walnut Grove occurred at 2 pm on February 20, slightly above the project flood stage of 14.5 feet.

In January 1980 a storm centered mainly over the Feather River basin and southward produced a rapid rise in the lower Sacramento River. On January 13 the release from Folsom increased from 30,000 cfs to 60,000 cfs between 10 a.m. and 2 p.m.. The stage at I Street reached 27 feet by 4 a.m. on January 14 and peaked at 28 feet four hours later when the Sacramento Weir gates were opened. The stage at Walnut Grove (estimated from the Isleton stage record) reached about 12 feet by 2 p.m. on January 16 and appears to have crested on the following day at a slightly higher stage. However, the stage at Walnut Grove was probably over 11 feet by mid-afternoon on the 14th.

The review of historical flood operations indicate lead times ranging from one to three days respectively, for removing the proposed barrier at Georgiana Slough based on a criteria of forecasted stage of 27 feet for the Sacramento River at I Street and/or a release greater than or equal to 40,000 cfs at Folsom. Use of a forecasted stage of 25 or 26 feet at I Street would increase the margin of safety. Additional lead time (with a greater risk of false warnings) could be produced by projecting Folsom inflow using Quantitative Precipitation Forecasts beyond 12 hours and anticipating USBR reservoir releases. These forecasts will require a higher degree of monitoring and forecasting refinements to develop relationships between I Street stages, Yolo Bypass flows, and the resulting stage at Walnut Grove.

The chances of needing the fish barrier removed are a little less than average this coming 1993 flood season because upstream major reservoir storage this fall will be much below normal.

Mitigation

Three interrelated measures are proposed to mitigate the threat of increasing flood risk. First, the threshold for removal of the test barrier has been conservatively linked to a forecasted warning stage (25 feet) for the Sacramento River at I Street. Second, the Department will provide for keeping a barge mounted crane with clamshell or dragline on-site throughout the period of flood risk which includes February and March. This measure virtually eliminates mobilization time in the event that the barrier needs to be removed. Third, the barrier will be constructed from erodible material in the event that rapidly rising flood waters arrive prior to complete removal of the barrier material by the crane. The remainder of the barrier would be eroded by the flowing water. Riprap will be placed for two hundred feet downstream of the barrier to prevent possible scour during the barrier removal (or failure) process, when high temporary channel velocities are possible.

3.8 Vegetation And Wetlands

Affected Environment

The vegetation in the vicinity of the proposed barrier location is typical of the north Delta study area. It is a mix of agricultural, riparian forest, riparian scrub-shrub, and heavily shaded riverine aquatic. To the west of the proposed barrier location, behind the Andrus Island levee, is a pear orchard. To the east lies the residential and commercial area of Walnut Grove. The channel banks of the slough are riprapped to about seven feet above mean sea level, with the exception of a gap on the east bank where erosion has removed it.

The channel banks, between the roads on the levee crowns and the water, were surveyed by Department of Water Resources staff to characterize the vegetation, delineate wetlands, if any, and to determine whether any special status plant species were present.

Sensitive plant species potentially occurring in this area include Mason's lilaeopsis (*Lilaeopsis masonii*), California hibiscus (*Hibiscus californicus*), Delta tule pea (*Lathyrus jepsonii* ssp. *jepsonii*), and bearded allocarya (*Plagiobothrys hystriculus*). A Natural Diversity Database retrieval showed no known rare plant occurrences along Georgiana Slough. A population of bearded allocarya is known to the Locke area, but this vernal pool species would not be expected on levee banks. Mason's lilaeopsis, Delta tule pea, and California hibiscus were not present in the vicinity of the proposed barrier installation.

Vegetation present in small areas between riprap sections included common rush (*Juncus effusus*), sedges (*Cyperus* and *Carex* species), and horsetail (*Equisetum arvense*). Vegetation on the upper levee banks is dominated by mixed upland grasses and herbs including oat (*Avena* spp.), barley (*Hordeum* spp.), bermuda grass (*Cynodon dactylon*), and Johnsongrass (*Sorghum*). Halepense perennial growth includes sweet fennel (*Foeniculum vulgare*), blackberries (*Rubus procerus*), and wild rose (*Rosa californica*). No elderberry bushes were present in this area.

Scattered shrubs and trees include willows (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), Fremont cottonwood (*Populus fremontii*), oak (*Quercus* sp.) and sycamore (*Platanus* sp.). Ornamentals are present around the private residences.

No jurisdictional wetlands were found in the vicinity of the proposed barrier location. Corps staff have indicated in preliminary consultation (personal communication, to Stein Buer from Jean Elder, 7/15/92 and to Cathy Crothers from Lou Cadwell, 7/23/92) that a wetlands delineation would not be required for Georgiana Slough downstream from the site, due to the short period of barrier installation and vegetation dormancy during most of that period.

Environmental Consequences

A small amount of woody vegetation growing between riprap rocks would be removed using hand tools, in order to provide a proper foundation for the barrier. This removal is judged to not be significant.

Mitigation

No mitigation is required.

3.9 Wildlife

Affected Environment

Swainson's hawk *(Buteo swainsoni)*, is a State threatened species known to nest in the Delta. DWR staff conducted a field survey to determine whether any Swainson's hawk nests were in the vicinity of the proposed barrier site. Several large cottonwood trees were found within 0.2 miles of the Georgiana Slough Bridge. Each tree was checked, and no raptor nests were found. The closest nest sites known to the DFG are near Steamboat Slough. These nests are out of the project construction area.

Table 3.9-1

Rare, Threatened, and Endangered Species Potentially Occurring in the North Delta Project Area

Common Name	Scientific Name	Status*	Distribution	Habitat
		PLANTS		
Suisun Marsh aster	*Aster chilensis var. lentus*	C2	San Pablo Bay, Suisun Marsh, Delta	Dense vegetation, stabilized substrate
Antioch Dunes evening primrose	*Oenothera deltoides* ssp. *howellii*	SE,FE	Delta	Sand dunes
Sanford's arrowhead	*Sagittaria sanfordii*	C2	Butte, Fresno, Sacramento, and Del Norte counties	Tule islands
Mason's lilaeopsis	*Lilaeopsis masonii*	C2, SR	Delta	Mudbanks
California hibiscus	*Hibiscus californicus*	C2	Delta & Central Valley up to Butte County	Freshwater marsh
Delta tule pea	*Lathyrus jepsonii* ssp. *jepsonii*	C2	Delta	Freshwater marsh
		ANIMALS		
Aleutian Canada goose	*Branta canadensis leucophareia*	FE	Western Delta, Modesto	Fresh and salt water marshes and waterways
Greater sandhill crane	*Grus canadensis tabida*	ST	Central Valley	Fresh water marsh, riparian areas, corn fields, near trees for nesting
California black rail	*Laterallus jamaicensis coturniculus*	C2, ST	Coast from Marin County to north Mexico; inland marshes	Fresh and salt water marshes
Tricolored blackbird	*Agelaius tricolor*	C2	Central Valley & Sierra Nevada foothills	Marshes, flooded lands, margins of ponds, grassy fields
Swainson's hawk	*Buteo swainsoni*	ST, C2	Lower Sacramento and San Joaquin valleys; Klamath Basin; Siskiyou County. Winters in South America	Grasslands, irrigated pastures, and open fields near trees for nesting
Giant garter snake	*Thamnophis couchi gigas*	C2, ST	Fresno County north through the Central Valley; east Delta	Freshwater marsh, riparian areas, rice fields, canals
Western pond turtle	*Clemmys marmorata*	C2	Throughout California west of Cascade–Sierra crest	Ponds and waterways lined with emergent vegetation

(Continued on next page)

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Table 3.9–1 (Continued)
Rare, Threatened, and Endangered Species Potentially Occurring in the North Delta Project Area

Common Name	Scientific Name	Status*	Distribution	Habitat
		ANIMALS (continued)		
California tiger salamander	*Ambystoma tigrinum californiense*	C2	Sonoma to Santa Barbara counties	Reservoirs, ponds, pools, lakes, and slow–flowing streams in grasslands and open woodlands
California red–legged frog	*Rana aurora draytoni*	C2	Coast, Transverse, Cascade, and Sierra Nevada ranges	Quiet, permanent water in woods, forest clearings, riparian areas, grasslands
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	FT	Lower Sacramento Valley north to Red Bluff	Elderberry bushes in riparian areas
Sacramento anthicid beetle	*Anthicus sacramento*	C2	Yolo, Solano, Butte, & Sacramento counties	Sand dunes near rivers
Delta smelt	*Hypomesus transpacificus*	C1, SC	Suisun & San Pablo Bays in early fall; spawns in channels & dead–end sloughs, December through April	Salinities usually less than 2 parts per thousand
Sacramento splittail	*Pogonichthys macrolepidotus*	(C2)	Suisun Bay from February—April; spawns in upstream dead end sloughs Jan–July	Slower currents; tolerates brackish water
Sacramento perch	*Archoplites interruptus*	(C2)	Sacramento–San Joaquin Delta; Russian River; Scattered lakes & reservoirs	Needs beds of rooted & emergent aquatic vegetation; tolerates alkaline water
Chinook salmon (winter–run)	*Oncorhynchus tshawytscha*	FT, SE	Sacramento River system	Cool fresh water with access to ocean

*Status: FT = federal threatened; FE = federal endangered; C1 = federal candidate with sufficient data to support federal listing; C2 = federal candidate currently without sufficient data to support federal listing; ST = State threatened; SE = State endangered; SR = State rare; SC = State candidate for protected status; (C2) = Currently being recommended by the Sacramento Endangered Species Office that the species be proposed as a C2.

Environmental Consequences

No impacts upon Swainson's hawk are anticipated. Other species of potential concern are shown in Table 3.9–1. However no other special status species are expected to be affected by the proposed barrier installation.

Mitigation

No wildlife impacts mitigation measures are required.

3.10 Fishery Resources: Salmon And Steelhead

Affected Environment

Chinook Salmon

The chinook salmon, *Oncorhynchus tshawytscha*, is the principal salmonid using the Sacramento–San Joaquin estuary. Chinook salmon produced in Central Valley streams are a valuable commercial and sport fisheries resource, making up the majority of ocean salmon catches in California and contributing significantly to ocean salmon fisheries along the coasts of Oregon and Washington. During 1977 through 1986, the contribution of Central Valley salmon stocks to California sport and commercial ocean harvest averaged approximately 400,000 fish.

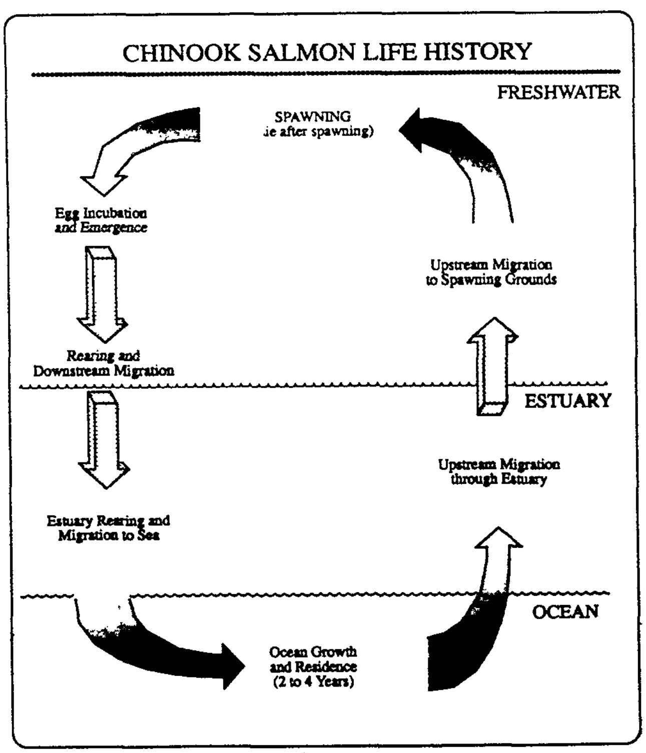

Figure 3.10–1. Chinook Salmon Life History

Although there is some natural and man–induced straying, the native runs within each river and stream are generally distinct from the runs in other rivers. Some Central Valley streams support multiple runs, which make their upstream spawning migrations at different times of the year. Figure 3.10–2 generally describes the timing of the life history elements of the Sacramento River salmon runs, named for the time of year adults enter fresh water on their spawning migration. After migrating, female salmon construct a nest (redd) and deposit the eggs which are fertilized by one or more males. The redds are covered and the spawning adults die in the stream of their origin.

Central Valley chinook salmon have an anadromous life cycle (Figure 3.10–1), spending most of their adult life in the ocean but migrating up Central Valley rivers and streams to spawn. Within the Sacramento–San Joaquin drainage there are several distinct populations (usually referred to as "runs") of salmon.

Steelhead Trout

Steelhead trout (*Oncorhynchus mykiss*) are an anadromous form of rainbow trout. They are a highly prized sport fish taken by anglers during the spawning runs in the main stem Sacramento River and its tributaries. The life history of Central Valley steelhead is similar to that of chinook salmon with a couple of major differences. Unlike chinook salmon, which inevitably die after spawning, steelhead may live to return to the ocean and perhaps spawn again. Also, juvenile steelhead generally remain in fresh water for 1 to 3 years before emigrating to the ocean. The run of steelhead into Central Valley streams is drawn out but continuous, extending from July to February, peaking in October and November. Like chinook salmon, steelhead generally return to spawn in the stream where they reared.

The Sacramento River drainage presently produces approximately 90 percent of all Central Valley chinook salmon and virtually all of its steelhead. Spawning occurs in all of the major tributaries to which salmon still have access (American, Feather, Bear, and Yuba rivers), the main stem of the Sacramento River below Keswick Dam, and in many smaller tributaries.

Sacramento River drainage stocks are the subject of intense management efforts mainly directed at controlling harvest and overcoming the negative effects of water development, land use changes, and poor water quality in the drainage. Most of these efforts, which include complex fishing regulations, three major hatcheries, diversion screens, fish ladders, and instream flow and temperature requirements, are focused outside the Delta. All four seasonal runs of chinook salmon use the drainage and pass through the Delta on their way out to sea as young smolts and upon their return as adults.

Two of the Sacramento River drainage runs are given more scrutiny. Fall run Sacramento River drainage salmon are important because they are the largest of the four runs, accounting for roughly 80 percent of total Central Valley salmon production. Winter run salmon are important because recent severe declines in their abundance have led to their classification as an endangered species by the California's Fish and Game Commission. The National Marine Fisheries Service (NMFS) is also considering classifying the run as endangered. This has, in turn, triggered intensified efforts, including those described later in this study, to improve their survival rates.

Fall run Chinook Salmon

Fall run chinook salmon adults enter the Delta on their upstream migration primarily during September through November using the scent of their natal stream to guide them to the spawning grounds. Their migration through the Delta is presently relatively unimpeded by human activities, although the diversion of Sacramento River water through the Delta Cross Channel and Georgiana Slough into the central Delta may cause some fish to stray temporarily into the lower San Joaquin and Mokelumne River systems, possibly delaying their migration.

Fall run salmon spawn above the Delta in late fall through early winter in the main stem Sacramento River and many of its tributaries as well as in the San Joaquin River System. Although access to much of the historically used spawning habitat has been eliminated by the construction of dams and the diversion of water, successful natural spawning still occurs in the rivers where appropriate temperature, flow, and gravel substrate conditions exist. In addition to the natural spawning, adult fish enter hatcheries on the American River, Feather River, and Battle Creek, where they are artificially spawned and their offspring reared.

Fall run salmon fry emerge from the gravel in late winter and begin the process of rearing and downstream migration. There is considerable variation in timing, both annually and among individuals, in the timing of downstream migration and location of rearing, apparently related to river flow conditions following emergence. Generally, if late winter–early spring river flows are high following emergence, there is a tendency for the young salmon (fry) to migrate or be transported downstream, where they rear in the lower river and Delta until they reach the smolt stage and are physiologically ready to enter salt water.

If normal or low flow conditions prevail following emergence, the fry tend to rear in the upper river areas until they reach the smolt stage and then make a rapid downstream migration through the lower river and Delta in late spring. DFG studies indicate that the contribution of salmon fry tagged in the upper river to the ocean fishery is positively associated with late–winter early–spring river flow.

Considerable effort has gone into studying the factors affecting the survival of fall run smolts during their downstream migration through the Delta. With fall run salmon, Kjelson et.al. found that water temperature, the proportion of Sacramento River flow diverted into the central Delta through the Delta Cross Channel and Georgiana Slough, and the total rate of exports by the CVP and SWP export facilities, all appear to be closely correlated with Delta smolt survival.

There are generally three routes Sacramento drainage smolts can take through the Delta during their downstream migration. As they enter the Delta they can: 1) remain in the main stem Sacramento River the entire distance to Suisun Bay, 2) leave the main stem Sacramento River at Sutter and Steamboat sloughs and continue down those channels to Rio Vista, and 3) leave the main stem Sacramento River through the Delta Cross Channel and Georgiana Slough and migrate through the central Delta. In tests of fall run salmon smolts taking the route through the central Delta generally survive at about one half the rate of fish taking the other two routes.

The mechanisms behind the relatively poor survival of fall run smolts migrating through the central Delta are not known at this time. Possible mechanisms include 1) generally higher spring water temperatures in the central and southern Delta, 2) a longer, more complicated migration route, 3) higher predation rates, 4) complications in navigation caused by the hydrological effects of export pumping, and 5) greater exposure to direct mortality at the CVP and SWP export facilities due to predatiòn, screening, and handling.

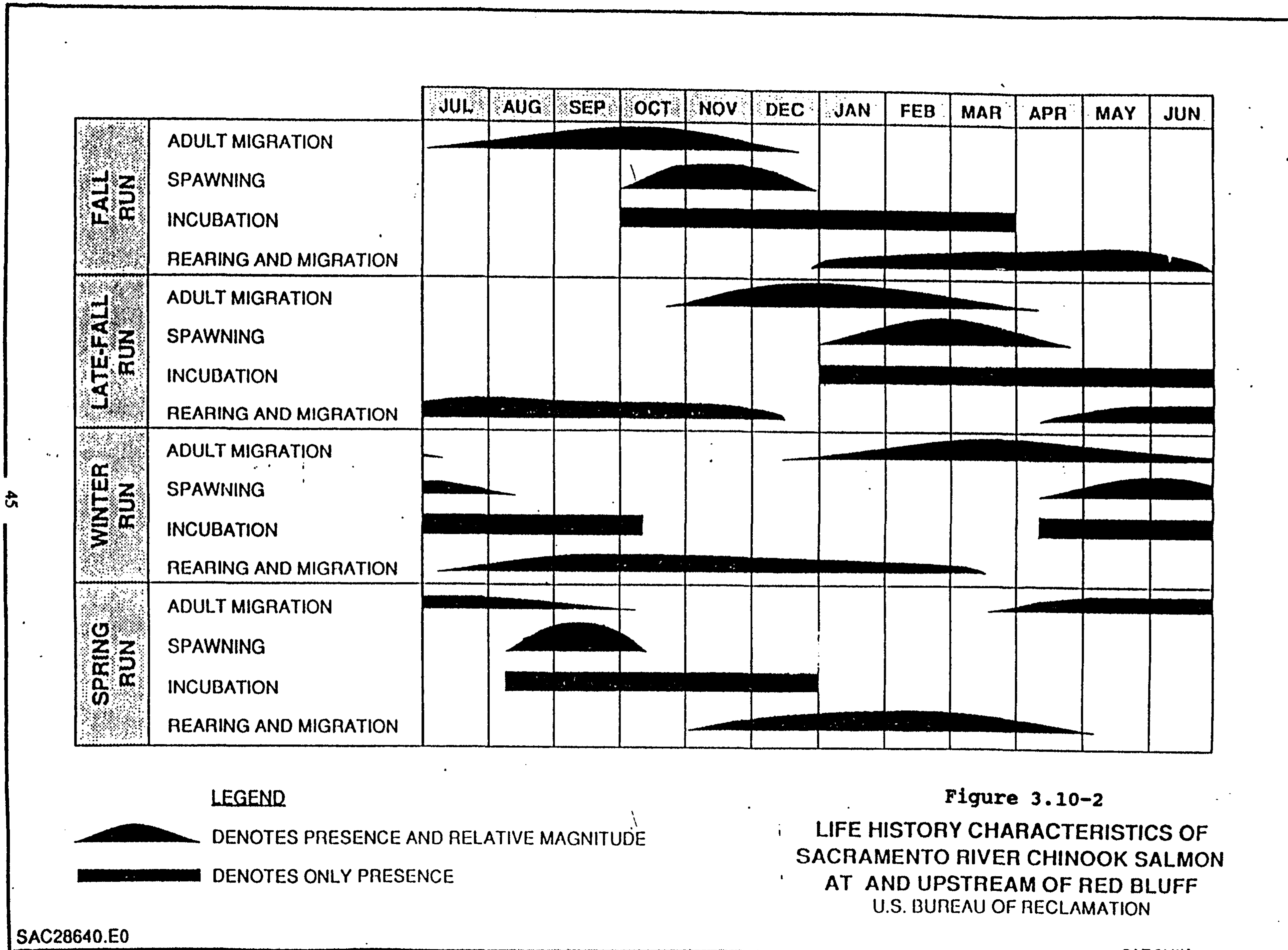

Figure 3.10–2. Life History Characteristics of Sacramento River Chinook Salmon at and Upstream of Red Bluff

Winter Run Chinook Salmon

The timing of events in the life cycle of winter run chinook salmon is quite different than that of the fall run salmon. Adult winter run salmon pass through the Delta principally during January through March, several months later than the fall run. Spawning occurs from mid–April to mid–August, peaking in late June or early July. Winter run fry begin migrating from the spawning areas in early September. Whereas fall run smolts typically pass through the Delta during April, May, and June, winter run do so during December through April, with the probable peak from January through March.

Winter run salmon spawning historically occurred primarily in the upper Sacramento, Pit, and McCloud river drainages, where relatively cool water temperatures prevail in the summer incubation period. The construction of Shasta Dam in 1942 prevented access to the historical spawning grounds, but summertime releases of cool water from the hypolimnion of Shasta Lake created favorable incubation conditions in the main stem Sacramento River below the dam and the winter run population probably increased in size.

The subsequent decline of winter run salmon has been attributed primarily to the operation of Red Bluff Diversion Dam, which prevented or delayed access to the favorable spawning ground below Shasta Dam. Another major problem for winter run salmon in some years is the increasing occurrence of higher water temperatures below Shasta Dam in summer and early fall. This condition occurs when the water levels are low in Shasta Lake and releases to the river come from warm surface waters. Other mortality factors include toxic discharge from Iron Mountain Mine, entrainment at poorly screened diversions, and stranding of juveniles during major flow fluctuations in the rearing area.

In 1988, a ten–point cooperative agreement was made between the USBR, USFWS, NMFS, and DFG to implement actions to improve the status of winter run chinook salmon in the Sacramento River Basin (Brown and Greene, 1992). Specific actions to be taken by the contributing parties are summarized from the agreement:

- Raise the Red Bluff Diversion Dam gates from December 1 to April 1. USBR will operate the gates so the timing for raising the gates will be designed to optimize the maximum practical benefits for upstream migrating winter run Chinook salmon. The parties will develop fish passage alternatives to raising the gates.

- Develop a water temperature control solution for warm water years in the Sacramento River. USBR is to develop and implement operational solutions to temperature control problems associated with Shasta Dam releases. This will include installation of a device to control the depth of water released from the dam.

- Correct the Spring Creek pollution problems. USBR, under a funding agreement with the Environmental Protection Agency, will develop the water management portion of the Spring Creek pollution control program. Pollution problems are associated with acid drainage from Iron Mountain Mine, located in the Spring Creek watershed.

- Restore spawning habitat in the Redding area of the Sacramento River. DFG will develop and fund a winter run chinook salmon spawning habitat restoration program.

- Correct salmon–related problems at the Anderson–Cottonwood Irrigation District Diversion Dam. DFG has already begun efforts to replace the diversion dam with an alternative method of supplying water to the district.

- Restrict in–river harvest of winter run chinook salmon.

- Develop a winter run chinook salmon propagation program at Coleman National Fish Hatchery.

- Modify the Keswick fish trap to prevent mortality to winter run Chinook salmon. USBR began modification to the fish trap in 1986.

- Develop measures to control squawfish predation at Red Bluff Diversion Dam.

- Continue and expand studies on winter run salmon. The parties will fund, develop, and implement studies to identify additional management actions to improve the status of winter run Chinook salmon in the Sacramento River.

Relatively little information is available on how conditions in the Delta affect winter run salmon. It is unlikely that water temperature is as important as it is for fall run smolts, because winter run smolts migrate through the Delta earlier in the year when Delta waters would be detrimentally warm. Due to periodic closure of the cross–channel gates from higher runoff levels during late winter and early spring, a smaller proportion of winter run smolts are diverted from the main stem Sacramento River into the central Delta through the Delta Cross Channel. However, like fall run smolts, the winter run smolts diverted into the central Delta via the Delta Cross Channel or Georgiana Slough will have a longer migration route.

Estimates of winter run smolt survival in the central Delta are not available. Current salvage estimates for winter run salmon involve stock identification based on size as the determining characteristic, although size alone, due to its high variability, is usually considered insufficient. The extent and significance of entrainment losses are not known at this time.

Environmental Consequences

The primary objective for installation of the proposed barrier at the head of Georgiana Slough is to improve the survival of downstream migrating winter run smolts. There is general agreement that this objective will be met by the barrier.

The benefit of barrier placement has been inferred from salmon fry and smolt release experiments, in which the young fish have been released from various locations in the Delta under various operating conditions.

Experimental releases made in the Sacramento River above the Delta Cross Channel at Courtland (Table 3.10–1) indicate that salmon released in the north Delta are entrained by the State and federal export facilities, but at relatively low rates in relation to the number of salmon released. The influence of the operation of the Delta Cross Channel on the extent of exposure of salmon smolts to increased entrainment at the SWP and CWP is not well understood. For instance, in 1987 with the Delta Cross Channel closed, 2.2 percent fewer fish were recovered at the SWP and CVP (.184 percent vs. .18 percent). However, in 1988 entrainment at the SWP and CVP increased by 132 percent (.45 percent vs. 1.02 percent). Nevertheless, even though entrainment only decreased 2.2 percent in 1987, survival, as measured at Chipps Island, improved by 68 percent, an increase from .40 to .67. In spite of the percent increase in 988, survival measurements at Chipps Island changed very little (2.8 percent or .72 vs .70).

In April 1992 experimental releases of CWT smolts were conducted at Ryde and in Georgiana Slough. The preliminary results of this study showed that smolt survival at Ryde release sites averaged about five times greater survival than the corresponding releases in Georgiana Slough (Table 3.10–2). In 1989, a model was developed to determine the relative importance of certain parameters on the survival of smolts migrating down the Sacramento River. The percent of water and salmon smolts diverted into the central Delta via the Delta Cross Channel and Georgiana Slough was found to be an important factor in determining the survival of smolts migrating through the Sacramento–San Joaquin Delta. Reducing this diversion into the central Delta by closing the Delta Cross Channel and Georgiana Slough is expected to improve the survival of smolts migrating during the period of closure.

Factors affecting survival of fall run salmon in the San Joaquin River and adjoining sloughs have been investigated through a number of release and recapture experiments. Releases were made in 1991 to evaluate differential survival rates for chinook salmon released at five locations in the San Joaquin River beginning at Dos Reis and extending west to Jersey Point. The data observed is not directly applicable to the Georgiana Slough Test Barrier Project because the conditions examined did not include key barriers associated with DWR's South Delta Temporary Barriers Project such as Old River at Head or Old River at Tracy. They do suggest that San Joaquin River fall run chinook salmon that are excluded from Old River by the barrier at its head will not be entrained by the SWP and CVP in significant numbers through alternate routes such as Turner or Columbia cuts.

San Joaquin River reverse flows are generally occuring at the time the salmon smolts are migrating downstream toward the ocean. Such reverse flows impede the ability of the salmon smolts to migrate to the ocean in a timely manner and in doing so increase their exposure time to the many mortality factors present in the south Delta (Table 3.10–2).

Recovery data from several groups of experimental fish releases in the San Joaquin River indicate that reverse flows throughout the Delta are affecting the survival of smolts emigrating from the San Joaquin River Basin. Tagged fish were released at Jersery Point during periods of no reverse flow (Table 3.10–3). Data from 1991, representing no reverse flow, yielded the highest survivals although low temperatures were also present at the time of CWT smolt release.

Table 3.10-1. Georgiana Slough Barrier Project. Percentage of CWT Chinook Salmon Smolts Recovered at the SWP and CVP from Fish Released in the Sacramento River

Year and Release Site	Cross Channel Gate Operation	Number Released	Percent Recovered SWP	Percent Recovered CVP	Chipps Survival
1986					
Courtland[1/]	Open	104,000	0	0.008	0.35
1987					
Courtland	Open	100,919	0.178	0.006	0.40
Courtland	Closed	100,202	0.142	0.038	0.67
Ryde[2/]	Open	51,008	0	0	0.88
Ryde	Closed	51,103	0	0.01	0.85
1988					
Courtland	Open	102,480	0.42	0.03	0.72
Courtland	Closed	107,249	0.94	0.08	0.70
Ryde	Open	53,238	0	0	1.28
Ryde	Closed	52,741	0	0	0.94

1/ Upstream of Cross Channel Gates

2/ Downstream of Cross Channel Gates

Table 3.10-2. Georgiana Slough Barrier Project. Preliminary Survival Indices and Ratios for CWT Salmon Smolts Released at Ryde and in Georgiana Slough in April 1992

	Ryde		Georgiana Slough	
Date of Release	Survival Index	Temperature at Release °F	Survival Index	Temperature at Release °F
4/6	1.36	64	0.41	64
4/14	2.15	63	0.71	64
4/27	1.67	67	0.20	67

Table 3.10-3. Survival Estimates for CWT Smolts Released at Jersey Point in the San Joaquin River Delta in 1989-1991.

	1989	1990	1991 April	1991 May
Low Exports (no reverse flows)	0.96	1.05	1.70	1.69
High Exports (reverse flows)	0.88	0.60		
percent increase	9	75		

Table 3.10-4. Georgiana Slough Barrier Project. Percentage of CWT Chinook Smolts Recovered at the State and Federal Fish Facilities by Release Site.

	RELEASE SITE		
HIGH EXPORTS	UPPER OLD RIVER	DOS REIS	JERSEY POINT
1989	6.9	5.0	0.2
1990	2.5	1.7	0.2
LOW EXPORTS			
1989	2.0	0.6	1.6
1990	1.3	0.1	0.1

Table 3.10–5. Comparisons of the Survival Indices (S_T) for CWT Chinook Smolts Released in the Sacramento River Above and Below the Opened and Closed Delta Cross Channel and Georgiana Slough Diversion Channels Between 1983 and 1989

	Year	Above[1/]	Below[2/]	Below/Above
Cross Channel Open	1984	0.61	1.05	1.7
	1985	0.34	0.77	2.3
	1986	0.35	0.68	1.9
	1987	0.40	0.88	2.2
	1988	0.72	1.28	1.8
	[3/] 1988	0.02	0.34	17.0
	1989	0.84	1.19	1.4
	1989	0.35	0.48	1.4
	1989	0.21	0.16	0.8
		Ave. = 0.43	Ave. = 0.81	Ave. = 3.4
Cross Channel Closed	1983	1.06	1.33	1.3
	1987	0.67	0.85	1.3
	1988	0.70	0.94	1.3
	1988	0.17	0.40	2.4
		Ave. = 0.65	Ave. = 0.88	Ave. = 1.6

[1/] Courtland Site (3.5 miles above Walnut Grove)

[2/] Ryde Site (3.0 miles below Walnut Grove)

[3/] Second release in 1988 was deleted for the purpose of calculation average for this analysis since survival indices appear to have been substantially influenced by extremely high temperatures in the north delta. This condition would not be expected to be a severe during the winter immigration.

Entrainment of smolts into the CVP and SWP export facilities appears to be greatest for fish released where they would have the greatest exposure to channels that carry water to the pumps. In addition, the evidence suggests that the entrainment is generally greater at higher export levels (Table 3.10–4).

Smolts released in the lower Sacramento River may have better survival rates than those released in the San Joaquin River for a given level of reverse flow.

While intended to improve the survival of outmigrating smolts, the barrier could also block the migration of winter run adults swimming upstream in the slough. The magnitude of this potential problem is unknown. Migrants which have started up the slough during the construction of the barrier, while there is still substantial flow, may be trapped. Even after the barrier is completed, it will not entirely block flow in the slough; seepage is expected to contribute 10 to 20 cfs of flow to the slough. This flow is expected to be at most a very weak

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attractant for adults seeking the Sacramento River (Kjelson, personal communication, 1992). Even with a total closure, straying adults may still find their way up the slough to the barrier.

Taking all these factors into consideration, the Georgiana Slough Test Barrier should provide a net benefit for Sacramento River races of chinook salmon smolts. Table 3.10–5 illustrates the expected benfit of the proposed project. Comparing survival indices for CWT smolt releases from 1983 through 1989, the benefit of closing the Delta Cross Channel alone is predicted to improve survival by 51 percent (0.65/0.43=1.51). Adding the Georgiana Slough barrier is predicted to improve survival by an additinal 35 percent (0.88/0.65=1.35). These benefits could be reduced depending on export rates. High export rates while the barrier is in place could increase the risk of reverse flows and increased entrainment of San Jaquin fall run chinook salmon smolts and fry in the south Delta. Once in the south Delta, they will likely be more vulnerable to entrainment at the SWP and CVP export facilities. During the time that the Old River at Head Barrier is in place, most smolts will escape to Chipps Island rather than enter the south Delta channels.

Mitigation

Upstream migrating adult winter run chinook salmon which might be trapped by the proposed barrier could be helped to pass either through the barrier or over the barrier. Two types of facilities have been considered:

- A fish ladder over the barrier
- Culverts for passage through the barrier

A temporary fish ladder could be provided over the barrier, but several difficulties would have to be overcome. First, unlike most fish ladder installations, water would have to be pumped to the top of the barrier to provide the flow down the ladder. A substantial flow, probably 20 cfs or more, would be required to fill a ladder large enough to attract the adult salmon. A substantial power supply and fish screens would be required for the water supply pumps. Possible configurations for a fish ladder include a chute with frequent baffles to produce high friction loss, or a cascade of large boxes with passageways between the boxes. It is not known how large a flow would be required or how large the ladder would have to be to attract the adult fish.

Culverts through the barrier could also provide a means for passage. One disadvantage is that the culverts could entrain downstream migrating winter run smolts, thus reducing the effectiveness of the barrier for that period when they are open. Here also is uncertainty about how large a culvert would have to be in order to attract adult migrants.

On the other hand, culverts would not require pumps, screens, and power supply, and thus would be far more practical for a short–term installation than a fish ladder. In addition, substantial attractant flows can be provided by selecting a culvert large enough. If appropriately configured, it is likely that one or more culverts through the barrier could provide an acceptable means of passage, although only by field testing could this be verified (personal communications with Marty Kjelson, Frank Fisher, and Phil Warner, 1992).

The culvert concept was selected as mitigation for potential obstruction of upstream migration. Based upon experience with fish passage facilities on the upper Sacramento River as well as the uncertainties involved in facilitating passage under the specific conditions in Georgiana Slough, the following features were incorporated (Figure 2–5):

- Two culverts are proposed, one 48–inch diameter culvert near the east bank, and one 72–inch diameter culvert near the center of the barrier. On the Georgiana Slough side, the culverts would include a flared transition piece, which would be flush with the barrier surface. This is intended to encourage the adults to enter the culverts. On the Sacramento River side, the culverts would protrude about 5 feet from the barrier face, with flap gates normally sealing them shut. Cables leading to floats could be pulled to open the flap gates when desired.
- The 72–inch diameter culvert would have welded plates protruding from the bottom at 20–foot intervals, to provide resting spots for the upstream migrants. A gap in the bottom of each plate would keep sediment from collecting and provide an alternative passage way (Figure 2–5).

The culverts would normally be closed. When monitoring in Georgiana Slough suggests the possibility of trapped adult salmon, the flap gates could be opened for an appropriate period.

3.11 Fishery Resources: Striped Bass

Affected Environment

The striped bass, *Morone saxatilis*, was introduced to the Bay/Delta in the late 1800s, when a few hundred juvenile

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fish, collected from the Navesink and Shrewsbury rivers in New Jersey, were planted. By the 1890s, the introduced fish had done so well that a commercial fishery had been established and more than 1 million pounds were landed in California 20 years after the transplant. From 1916 to 1935, the annual commercial catch ranged from 500,000 to 1 million pounds. Commercial fishing continued until 1935, when it was stopped to provide a better striped bass sports fishery. There has been a recent general decline in angler success, because of a substantial decline in the adult striped bass population during the 1970s.

This section provides a general description of striped bass life history, current status of the population, a description of the factors thought to control striped bass abundance, and an analysis of the impacts of the test barrier project.

Much of the detailed information regarding striped bass has been collected as part of a 1960s DFG/DWR cooperative study and an interagency (DWR, DFG, SWRCB, USGS, USBR, USFWS) study (1971 to date) of the Bay/Delta. Striped bass are collected and abundance indices are developed for various life stages from eggs through adults. Information is also collected on food supply, entrainment, and such environmental variables as the water's oxygen content, clarity, and salinity. Recent work by Stevens et al. (1990) provides additional analysis of the available data on the striped bass decline.

Unlike many East Coast populations, especially those from the Chesapeake Bay, California striped bass apparently spend most of their life cycle in the Bay/Delta and in the coastal ocean within a few miles of the Golden Gate. Striped bass have been caught as far south as Redondo Beach (Los Angeles County) and as far north as the State of Washington, indicating that some limited ocean migration has occurred. A small self-sustaining population was established in the Coos River in southern Oregon; however, their numbers have decreased dramatically in recent years.

Potential Factors Affecting Striped Bass Abundance:

Food Supply
- Lower algal levels
- Change in algal bloom species
- Introduction of nonnative invertebrates
- Lower levels of important native invertebrates

Egg Production
- Lower numbers of fish
- Lower numbers of older fertile females

Adult Mortality
- Natural (including old age, disease, poaching, and toxics)
- Fishing

Toxics (from urban, industrial, mining, agricultural, and other sources)
- Treated waste
- Untreated waste
- Point runoff
- Non-point runoff

Entrainment
- State Water Project
- Central Valley Project
- Delta agriculture diversions
- West Delta Power Plant Diversions

Delta Cross Channel Operation

Outflow and Diversion Rates

Some adult striped bass move from San Francisco Bay in the fall, while others remain in the Bay and migrate to the Delta later. In the spring, adults undergo a spawning migration to the lower San Joaquin River and the Sacramento River between Isleton and Butte City. DFG has estimated that about 60 percent of the bass spawn in the Sacramento River and 40 percent spawn in the lower San Joaquin River.

For this analysis, adult bass are defined as those exceeding the minimum legal catchable size of 18 inches. About half of the bass reach this size at 3 years of age. Males can begin spawning at two years of age, but females are generally five years or older. The number of eggs per female (fecundity) varies directly with size and age and can range from a few hundred thousand for a young female to a few million for females older than 10 years.

Since spawning is regulated to a large degree by water temperature during the April-June period, the time of peak spawning varies from year to year and may show several peaks within a year. Spawning may also be limited by salinity; most spawning occurs at salt concentrations of less than 200 mg/l total dissolved solids (TDS).

The female broadcasts the eggs into the water, and after fertilization by the male, the developing embryos drift with the current. After hatching from the egg, the larvae are small (3-5 mm) and depend on food originally available in the egg. Mortality from all sources during this period is very high, at times in excess of 50 percent per day. The larvae begin to feed at the 5-7 mm stage (about

10 days to 2 weeks after fertilization). Survival at this time may depend on whether the larvae are transported to an area where food of the right size and concentration is available. Larval bass initially depend on small crustaceans (part of the zooplankton) for food. As the bass grow, they are able to capture larger zooplankton, such as the mysid shrimp (*Neomysis mercedes*) and later, small fish.

By the end of July, the juvenile bass have grown to the 30–40 mm size range and are found mostly in the Delta, Suisun Bay, and Montezuma Slough (in Suisun Marsh). Most of the young bass remain in the upper estuary (San Pablo Bay through the Delta) during their first two years of life.

Some mechanism is probably present to maintain adult population stability in spite of variations in year class strength, since there is an apparent lack of correlation between the 38 mm index and subsequent abundance of 4–year–olds from the same year class. This differentiation between juvenile and adult abundance is also demonstrated by the indices themselves; i.e., the 38 mm index varied about tenfold (from 117 to 9) during 1965 through 1983, whereas the population of 4 year olds only varied by a factor of 3 (from about 600,000 to 200,000).

Although the 38mm index is not correlated to the subsequent abundance of 4–year–olds from the same year class, DFG has found that it is closely correlated to an index of the abundance of 4–year–old bass. Fishery biologists do not agree on which of these two methods better reflect the relationship between the abundances of 38 mm and adult striped bass.

Environmental Consequences

Hydrodynamic modeling results and entrainment data used in analyzing barrier effects upon chinook salmon resources, as well as the results of salt transport modeling conducted to assist the Article VII process were used to evaluate potential impacts to striped bass.

Although not a diversion in the typical sense, the diversion of water from the Sacramento River to the interior Delta via the Delta Cross Channel and Georgiana Slough has the potential to adversely impact striped bass. This conclusion comes from analyses showing that in recent years the Delta has become a less hospitable nursery area for young striped bass. It appears that projects resulting in more eggs and larvae, drawn to the interior Delta could adversely impact year–class strength. As is apparent from the preceding discussion, that hundreds of millions of eggs, larvae. and juvenile striped bass are lost annually to diversions from the Sacramento River, the Delta, and Suisun Bay. The impact of these losses on adult population numbers is difficult to determine. Because striped bass are prolific spawners, the species has evolved in a manner that allows for over 99 percent mortality between eggs and adults while still maintaining a level population.

The above discussion does not mean that juvenile production is unimportant to adult striped bass abundance. DFG recently introduced a model attempting to equate adult striped bass abundance to the young of the year (yoy) index, export bases, and the loss rate index using weighted means. Currently, there are questions about the validity of the model which need to be resolved before applying it to existing data and trying to predict future striped bass abundance. DFG also believes that entrainment losses are having an impact on egg production through cumulative effects on the numbers of adults. They also believe entrainment losses of juvenile stripped bass are affecting numbers of adult striped bass.

It has long been hypothesized that reverse flows may have a negative impact on young striped bass and their food supply. Reverse flows could impact striped bass by drawing young fish to the export pumps from spawning and nursery areas in the central and western Delta. The change in flow pattern could also adversely affect bass habitat or food supply in the lower San Joaquin River, although these effects have yet to be demonstrated.

The possible role of reverse flows in drawing young striped bass to the export pumps is supported by the statistical evaluation by Wendt (1987). That study indicated there was a significant inverse relationship between flow in the lower San Joaquin River and the number of young bass salvaged at the Banks Pumping Plant in June and July.

Mathematical modeling studies were also conducted to analyze the effect of Georgiana Slough closure on striped bass eggs and larvae. The model runs evaluated the transport and distribution of salinity tracer pulses injected at various points in the Delta. The salinity tracer pulses simulated concentrations of eggs and larvae, which are passively transported and distributed by the flowing water. While this approach is useful for comparision of alternatives, limited verification of egg and larvae transport and distribution in the Hudson River has indicated that the eggs and larvae move more slowly than predicted by the model. Also, the model does not take into account predation on and mortality of the eggs and larvae in the Delta channels—only losses due to diversions. Thus in the context of these studies, "survival" is used as an indicator of mass transport, dispersion and retention in Delta or Bay waters, not as an indicator of viability.

The studies, which were based upon assumed dry year conditions for the month of May, suggested that striped bass eggs released at Vernalis had a 30 day survival of less than one percent. No significant change in this result is expected with the installation of Georgiana Slough Test Barrier.

Modeling of Sacramento River egg and larvae transport suggested that eggs released at Sacramento had a 30 day survival of more than 62 percent, with the eggs located in Delta channels or west of Chipps Island (Table 3.11−1). Just over 25 percent of the tracer released was taken up by state and federal export facilities. Closure of the Delta Cross Channel and Georgiana Slough is predicted to reduce these losses by reducing the drafting of striped bass eggs and larvae into the north, central and west Delta channels.

Table 3.11−1. Georgiana Slough Barrier Project. Percent Tracer Found From Sacramento River Release

Day	Swp	CVP	CCC	Island	Total
10	0.26	0.14	0.04	6.18	6.62
20	7.70	5.64	0.72	9.05	23.11
30	14.46	11.02	1.20	11.24	37.92
40	17.37	13.36	1.4	12.29	44.42

Modeling of eggs and larvae released directly into the central Delta suggested a 30 day survival of 63 percent, approximately the same 30 day survival as that of eggs released in the Sacramento River. The remainder was was taken up by CVP, SWP, and other diversions from the Delta.

In summary, the transport modeling indicates little difference in relation to base conditions for San Joaquin River and Sacramento River simulated releases of striped bass eggs and larvae. However, with installation of the Georgiana Slough test barrier, losses of eggs and larvae originating from the Sacramento River are expected to decrease. On the other hand losses of eggs released into the Delta are expected to increase if export levels are high and reverse flows substantial in the lower San Joaquin River. As suggested by verification of Hudson River modeling, the model probably over estimates impacts.

Mitigation

No mitigation is required. However, extensive monitoring and project operations modeling will be conducted to help evaluate potential short and long term impacts.

3.12 Fishery Resources: American Shad

Affected Environment

American shad were first introduced into the Sacramento−San Joaquin River System in 1871. The initial plant of about 10,000 young of the year was followed by additional plantings, totaling 819,000 from 1873 to 1881 (Skinner 1962).

The American shad population increased rapidly and soon supported a major commercial gill net fishery in the estuary during the spawning runs. American shad were sold in San Francisco markets by 1879. Catches regularly exceeded 1 million pounds from 1900 to 1945; about 5.6 million pounds were taken in 1917. After 1945 the fishery diminished, and in 1957 it was terminated by legislation due to public concern about the impact of the gill nets on striped bass (Skinner 1962).

Although American shad were commercially important, enthusiasm for sport fishing did not begin until the 1950s, when anglers began fishing the spawning grounds in the upper Sacramento and San Joaquin river systems, particularly the main stem Sacramento, and the American, Feather, and Yuba rivers. Once established, the popularity of shad fishing grew, and by the mid−1960s, an estimated 100,000 angler days were being expended annually (California Fish and Game 1965). However, more recent surveys in 1977 and 1978 indicate that about 35,000 and 55,000 angler days were expended to catch 79,000 and 140,000 shad, respectively (Meinz 1981). The present bag limit is 25 fish per day, but most anglers typically release all, or most of, their catch. The American shad spawning run was estimated to be 3.04 million in 1976 and 2.79 million in 1977 (Stevens et al. 1987).

American shad are anadromous, living primarily in the Bay and ocean as adults but using fresh water for spawning and nursery grounds. Historically, shad spawned throughout Delta fresh waters and upstream into both the Sacramento and San Joaquin rivers, but spawning has declined in the San Joaquin system, leaving the north Delta and Sacramento system upstream from Hood as the primary spawning areas.

Adults returning from the ocean begin passing through the Delta in late March or April (Stevens 1966). In fyke traps set in the Sacramento River at Clarksburg, American shad catches increase substantially through April and peak during May (Stevens et al. 1957). River temperatures during May generally range from about 57° to 75° F.

River flow may affect the distribution of American shad on their initial spawning runs in the Sacramento River system.

The shad fishery is also affected by the distribution of adult fish. Hence, low spring flows in the American, Feather, and Yuba rivers not only reduce their shad runs, but also angling opportunities. Most repeat spawners in the Sacramento River system probably home to the tributary where they have spawned previously. Sampling of American shad eggs with nets set in the Feather River indicates that spawning occurs predominantly from May to July at temperatures of 63° to 75° F. (Painter et al. 1977).

The flow in most of the spawning areas washes the demersal but free–drifting eggs a short distance downstream before they are hatched. The main summer nursery of American shad appears to extend from Colusa on the Sacramento River to the north Delta, including the lower Feather River; some numbers of fish also use the south Delta.

In wet years, young shad are less likely to use the Sacramento River, and more likely to use the north Delta than in dry years. This difference probably reflects the transport of eggs and young fish by river flow and indicates that annual flow differences cause the location of major concentrations of fish to vary (DFG 1987).

Although the food habits of juvenile American shad in California have not been studied extensively, Ganslee (1966) reported that *Neomysis*, copepods, larval fish and *Corophium* sp. were the primary food items found in the stomachs of a small sample of juvenile shad captured in the west Delta.

The food habits of juvenile American shad rearing in the upper Sacramento River and tributaries are not known, but studies conducted in East Coast rivers found young shad eating a wide variety of insects and zooplankton (copepods and cladocerans) with the diet of a particular population dependant on the prey items available (Walburg 1957, Massman 1963).

It is likely that shad in California have a similar flexible feeding strategy. During the time they are rearing in zooplankton–poor areas upstream of the Delta, shad probably depend primarily on insects originating in the wooded area surrounding the Sacramento River and its tributaries (Turner 1966). Shad rearing in or moving through the more open water areas of the Delta and west Delta would feed on zooplankton originating in the Delta waters.

Both sources of juvenile American shad food are threatened by human development. Continued removal of riparian and streamside vegetation in the Sacramento River system upstream from the Delta potentially reduces the amount of insect drop supporting young shad in those regions. Water development has reduced the abundance of zooplankton in the Delta, primarily because the use of Delta channels as conduits to carry water south to the CVP and SWP pumps has increased flow velocities, reduced water residence times, and brings large volumes of zooplankton–deficient Sacramento River water into the central and south Delta (Turner 1966, Turner and Heubach 1966, Heubach, 1969, Knutson and Orsi 1983, Orsi and Mecum 1986).

Abundance of young American shad in the Sacramento–San Joaquin Estuary varies annually by more than an order of magnitude, and the strongest year classes occur in the years with the highest river flows during the spawning and nursery period (Stevens and Miller 1985). Flows during April–June appear to be most important in explaining year–to–year variation in abundance.

Environmental Consequences

Young American shad are vulnerable to diversion by the State and federal pumping plants in the south Delta. Juvenile shad spawned in the south Delta and Mokelumne River channels would be drawn to the pumps as larvae and newly metamorphosed small fish, whereas Sacramento system juveniles tend to be drawn through the Delta Cross Channel and across the Delta during their downstream migration. From 1968 through 1985, American shad have been the third most common fish at the SWP fish facilities, with annual recoveries as high as 3

Table 3.12–1. Georgiana Slough Barrier Project. Period of Barrier Operation and Critical Periods to American Shad

American Shad

	Jan	Feb	Mar	Apr	May	Jun	Jul
Eggs							
Larvae							
Juveniles							
Adults							

Proposed Project

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Georgiana Slough Barrier								

million. In 1967, CVP recoveries exceeded 8 million (DFG 1987).

Figure 3.12–1 displays the critical periods for the various life stages of American shad in comparison to propose barrier operation. Using the results of the salt transport and hydraulic modeling as well as past salvage data, increases in impacts to the American shad using the north and central Delta are anticipated. Egg and larval shad spawned in the Delta are not expected to be impacted through entrainment at the CVP and SWP facilities or other diversions since the barrier will be removed prior to spawning. Juvenile and adult shad will likely be entrained at greater rates since the changes in hydraulic conditions in the central Delta will likely result in a greater risk to shad in the area. Disorientation, increased predation, and increased entrainment at agricultural diversions could occur.

Mitigation

No mitigation action is required. However, extensive monitoring and project operations modeling will be conducted to help evaluate potential short and long term impacts on American shad.

3.13 Fishery Resources: Sturgeon

Affected Environment

Two sturgeon species, white sturgeon (*Acipenser transmontanus*) and green sturgeon (*Acipenser medirostris*), inhabit the estuary. Both are native, anadromous species. At this time a reasonable assessment of project impacts can only be made for white sturgeon, because very little is known about the biology of green sturgeon in the estuary. The white sturgeon population is presently supported entirely by natural reproduction.

The white sturgeon population in the estuary supports an increasingly popular sport fishery, in great part due to the large size individual fish attain. The current California sportfishing record for this species is a fish caught in Carquinez Straits during the mid–1980s that weighed over 450 pounds. The number of legal size (>40 inch) white sturgeon in the estuary has been estimated eight times since 1954. These estimates have fluctuated from 11,200 in 1954 to 128,300 fish in 1984. The annual sport fishing take in the estuary in recent years has averaged about 10,000, roughly 10 percent of the estimated legal size stock population (Kohlhorst et al. 1990).

White sturgeon generally complete their life cycle within the estuary and its major tributaries, although a few fish enter the ocean and make extensive coastal migrations. During most of the year, adult white sturgeon are concentrated in San Francisco, San Pablo, and Suisun bays, feeding principally on bottom–dwelling invertebrates, such as clams, crabs, and shrimp. Mature sturgeon ascend the Sacramento River, the Feather River, and possibly the San Joaquin River to spawn, primarily during March and April. Spawning in the Sacramento River occurs primarily above the town of Knights Landing, historically extending upstream above the present location of Shasta Dam. Presently, most spawning occurs between Ord Bend and Knights Landing, although some fish migrate above the Red Bluff Diversion Dam to spawn when the dam gates are open (Kohlhorst 1976).

White sturgeon make spring migrations into the San Joaquin River between Mossdale and the mouth of the Merced River. While these migrations could be for spawning, no collections of eggs or larvae have been made to confirm this (Stevens and Miller 1970).

White sturgeon spawn over rock and gravel, to which the fertilized eggs adhere. After hatching, there apparently is a general downstream movement of young fish into the upper estuary, but the details of this migration are not known. It has been observed that in years of high river flow, larval sturgeon are more abundant in the upper estuary than in dry years, suggesting that river flow may play a role in the dispersal of young sturgeon from the spawning grounds. The upper estuary, Suisun Bay, and the Delta are apparently the principal nursery areas for sturgeon during their first year of life (Stevens and Miller 1970).

White sturgeon are particularly vulnerable to the effects of over–harvesting because they mature slowly. Female white sturgeon do not reach sexual maturity until they are at least 15 years old and about 4 to 5 feet long. Commercial fishing in the late 1800s and early 1900s led to a decline in the sturgeon stock, prompting a prohibition on all fishing from 1917 through 1954. In 1954, the Fish and Game Commission established a sport fishery, which continues to the present. For most of the period since 1954, there has been a creel limit of one fish per day and a 40–inch minimum size limit. In response to recent increases in the amount and efficiency of recreational angling for sturgeon, the Fish and Game Commission adopted more restrictive regulations in 1990, raising the minimum size limit to 42 inches and establishing a maximum size limit of 72 inches. The minimum size limit will likely be raised by 2 inches each year until it reaches 48 inches.

Observed fluctuations in the sturgeon population since 1954 appear to be due primarily to variations in recruitment (the production of young fish) rather than variations in the annual survival rates of older age classes (Kohlhorst 1990). Furthermore, it appears that the size of the spawning stock and survival during the first few months of the life cycle are the principal determinants of year class strength. Adult age distribution, catches of juvenile sturgeon at the SWP fish salvage facilities, and juvenile sturgeon occurrence in DFG's Bay study trawl samples all suggested that annual production of young sturgeon varies widely and that production is positively associated with flow conditions in the spring spawning and rearing period.

The mechanism responsible for the positive association between sturgeon year class strength and outflows is not well understood. The April through May period encompasses the latter part of the spawning season through the ear ly larval and juvenile stages. River flow could be important during this period, since spawning, hatching, and early rearing take place in the upper river, but the high degree of correlation between Sacramento River flow and outflow makes it difficult to separate the effects of the two factors.

Very little is known about the habits and needs of white sturgeon in their early weeks of life. It has been observed that larval sturgeon are more abundant in the Delta during high flow years, suggesting that high flows transport them there. If survival in the estuary is greater than in upstream areas, it could explain the associations between spring flow and fall abundance. Using Dingall/Johnson funds, DFG has recently initiated studies to develop better estimates of year class strength and to better document the spawning and early life history of white sturgeon.

Environmental Consequences

Few sturgeon are salvaged at the fish screens of the CVP and SWP export facilities. Although there may be an increase in losses as a result of the test barrier project, the magnitude of the increase is expected to be small. This is likely since no increased flows are expected into the central and south Delta from the Sacramento River. Based on what is known about white sturgeon adult movement in the Delta, these movements are not expected to be affected by barrier placement. The net eastward movement of potential food sources for juvenile white sturgeon, such as *Neomysis* could also be detrimental for the same reason as discussed for striped bass.

Mitigation

No mitigation is required.

3.14 Fishery Resources: Smelt And Other Resident Fishes

Affected Environment

Resident fishes as defined here, are nonanadromous (nonmigratory) species which complete their life cycle in the Delta and the lower reaches of its tributary rivers.

The Delta itself is not a totally fresh water system, year round. Therefore species that might be termed brackish water species, such as tule perch, are included here. These species are usually found in fresh water, but can withstand periods of higher salinity.

Central California is dominated by the large and diverse Sacramento–San Joaquin River drainage system. Because it is isolated from other systems, by coastal mountain ranges, the Cascades, and the Sierra Nevada, a unique fresh water fish community evolved. Seventeen species of fresh water fish are endemic to the system and live nowhere else (Moyle 1976). Eleven of these are resident species in the Delta.

The resident native species of the Delta evolved to live in the stagnant backwaters, shallow tule beds, deep pools, and long stretches of slow–moving river waters of the Delta of the past (Moyle 1976). Land reclamation, introduction of exotic species, and water project operations have changed conditions in the Delta. Many native fishes have either become extinct, such as the thicktail chub, or survive in greatly reduced numbers, such as the Sacramento perch.

Native Fishes

Five native resident species that are found in the Delta are members of the family Cyprinidae, commonly known as minnows (Table 3.14–1). Two of these minnows, the Sacramento squawfish and hardhead, along with the Sacramento sucker, were historically abundant in the Delta (Moyle 1976). Presently Sacramento squawfish and hardhead are now found in low numbers. This reduction is due mostly to habitat changes, but competition from introduced species also contributed (Moyle 1976).

Minnows are usually thought of as small fish, less then 10 cm; however, many native minnow species in western North America are large. Hitch, Sacramento blackfish, and Sacramento splittail commonly reach 20–35 cm, 35–45 cm, and 30–40 cm in length, respectively. All native minnows were once heavily fished for food by native Americans (Moyle 1976). Formerly there was a small commercial fishery for Sacramento splittail and Sacramento blackfish, and the Sacramento blackfish is still harvested commercially from Clear Lake and San Luis Reservoir. Both species have potential for aquaculture. There are presently recreational fisheries for tule perch, squawfish, Sacramento splittail, and Sacramento sucker in the Delta and the lower American and Sacramento rivers.

Sacramento Splittail

The Sacramento splittail is a native minnow that lives mostly in the slow–moving stretches of the Sacramento River up to Red Bluff Diversion Dam, the Delta, and in the Napa and Suisun marshes (Moyle 1976; DFG unpublished data). After high flows they have been found in Suisun Bay, San Pablo Bay, and Carquinez Straits (Moyle 1976). Turner (1966) reported finding them evenly distributed in the Delta, while a later study found them most abundant in the north and west Delta on flooded island areas in association with other native species (DFG 1987).

Sacramento splittail are tolerant of brackish water, being caught at salinities as high as 10–12 parts per thousand (ppt) (Moyle 1976). During spring, they congregate in deadend sloughs of the marsh areas of the Delta, and Napa and Suisun marshes, to spawn over beds of aquatic or flooded terrestrial vegetation (Moyle 1976; DFG unpublished data). They have been observed to migrate up the Sacramento River and spawn on the grass at Miller Park (DFG pers. comm.)

Longfin Smelt

The Sacramento–San Joaquin River Delta has two native, resident species of smelt: the longfin smelt and the Delta smelt. The longfin smelt, *Sperinchus thaleichtys* is euryhaline. In the Sacramento–San Joaquin Estuary they can be found in water ranging from nearly pure sea water to completely fresh water. However, they are most abundant in San Pablo and Suisun bays, where saliniites normally are greater than 10 ppt. Longfin smelt occupy mostly the middle or bottom of the water column. They also have definite seasonal migrations, spending early summer in San Pablo and San Francisco bays, and then moving into Suisun Bay in August. In the winter they congregate for spawning at the upper end of Suisun Bay and in the lower reaches of the Delta. There is a mass movement of young smelt downstream into the bays in April and May (Moyle 1976).

The main food of the longfin smelt is the opossum shrimp, although copepods and other crustaceans are important at times, especially to small fish (Moyle 1976).

Table 3.14–1. Resident Fish Species of the Sacramento–San Joaquin Delta			
Centrarchidae	**Ictaluridae**	**Cyprinidae**	**Others**
Largemouth Bass	White Catfish	Hitch*	Sacramento Sucker*
Smallmouth Bass*	Channel Catfish	Sacramento Blackfish*	Tule Perch*
Spotted Bass	Brown Bullhead	Sacramento Splittail*	Bigscale Logperch
Bluegill	Black Bullhead	Sacramento Squawfish*	Inland Silversides
Redear Sunfish		Golden Shiner	Mosquitofish
Green Sunfish		Goldfish	Threespine Stickle-back*
[illegible]			
Warmouth		Carp	Prickly Sculpin*
Black Crappie		Hardhead*	Delta Smelt*
White Crappie		Fathead Minnow	Threadfin Shad
Pumpkinseed			Yellowfin Goby
Sunfish Hybrids			
Sacramento Perch*			

**Indicates native species.*

Delta Smelt

The Delta smelt is found in the more fresh water areas. A recent and continued dramatic decline in its abundance led to the recommendation that it be listed as a threatened species (Stevens et al. 1990). The Fish and Game Commission rejected this recommendation, pending more information of the species status.

On October 3, 1991, the USFWS proposed to list the Delta smelt as a threatened species pursuant to the federal Endangered Species Act. Comments on the proposal have been received and the USFWS will make a determination on whether to list the species in October, 1992, or may extend the date to April, 1993.

The Delta smelt is found only in the Sacramento–San Joaquin River Estuary. Most of the year the population is found in the San Joaquin River below Mossdale, in the Sacramento River below Isleton, and in the Suisun Bay and marsh region. They are also found in Carquinez Strait and San Pablo Bay when high river flows move the salinity gradient downstream. Delta smelt have been found at salinities as great as 10 ppt, but most of the population occurs in waters with lower salinities. They school in open surface waters (Moyle 1976).

Delta smelt appear to be opportunistic feeders on planktonic copepods, mostly the native *Eurytemora affinis*, and on the introduced *Pseudodiaptomus forbesi* in years when it occurs in high abundance (Stevens et al. 1990). Also included in the diet are cladocerans, amphipods, and insect larvae. When the population moves downstream to Suisun Bay, the opossum shrimp, *Neomysis mercedi*, becomes an important food item (Moyle 1976).

The majority of spawning occurs in the deadend sloughs, the shallow edge–waters of Delta channels, and in the Sacramento River from February through June. Spawning occurs in fresh water at temperatures of 7–15° C. Females produce 1,400–2,900 demersal, adhesive eggs on rock, gravel, tree roots, and submerged vegetation. After hatching, larvae drift downstream to the mixing, or entrapment zone. Growth is rapid, with juveniles r eaching 40–50 mm long by August. Adult lengths, 55–77 mm, are reached when fish are 6 to 9 months old (Stevens et al. 1990).

Delta smelt larvae and prespawning adults generally occupy the brackish water areas downstream of the Delta, particularly in Suisun Bay. The summer–fall geographical distribution is strongly influenced by Delta outflow. As outflow increases, more of the population occurs in Suisun and San Pablo bays; in low flows the population is confined to the channels of the Delta.

As spawning approaches in the late winter and spring, Delta smelt adults migrate to fresh water. Most spawning occurs in the upper Delta, including deadend sloughs and shallow water, in Montezuma Slough near Suisun Bay, and in the Sacramento River upstream of Rio Vista (Radtke 1966, Wang 1986). Delta smelt are a short–lived species; most die after spawning at one year of age, but some survive to two years.

Until very recently, Delta smelt were abundant in the Delta. During the 1980s, however, the population decreased substantially. Delta smelt populations have declined in the past, but there are indications from the fall migration trawl survey that adult populations may have recovered somewhat during the past few years. The population reductions began in the south and east Delta during the 1970's, prior to the overall population decline of the 1980s. (Stevens et al. 1990).

Data indicate that abundance of a Delta smelt year class largely depends on environmental conditions affecting survival of eggs and young fish, rather than the abundance of adult spawners. However, to investigate the cause of the population decline, DFG evaluated the following factors: Delta outflows, food supply, reverse flows, water temperatures, and water transparency. The analysis was unable to point to any one environmental factor as controlling Delta smelt population abundance (Stevens et al. 1990).

Many native resident fish species are most abundant in the north and west Delta (DFG 1987). These species often have life histories that are similar to that of the Delta smelt. They spawn in deadend sloughs, eggs are adhesive and demersal, and the larvae are planktonic. Impacts of the Georgiana Slough Barrier Project on these species would be similar to its effect on Delta smelt.

Tule Perch

The tule perch is the only fresh water species of the surf perch family, Embiotocidae. Tule perch are euryhaline and have been caught in salinities of up to 18 ppt (DFG unpublished data). The surf perches are livebearers; the tule perch gives birth to about 20–80 young in May or June (Moyle 1976). They can live in a various habitats, varying from sluggish, turbid channels in the Delta to clear, swift–flowing sections of river. They are able to live in fast water by taking advantage of eddies that occur behind submerged boulders and logs. They prefer beds of emergent aquatic plants or overhanging banks (Moyle 1976). Tule perch eat small invertebrates that are found on the substrate or in midwater (zooplankton); tule perch consume mostly amphipods, midge larvae (Chironomidae), and small clams and crabs (Moyle 1976).

Tule perch are native to low elevation waters of the Sacramento–San Joaquin river system, as well as to Clear Lake, Coyote Creek, and the Russian, Napa, Pajaro, and Salinas rivers (Moyle 1976). DFG (unpublished data) found them to be the fifth most abundant species in the Napa River during the 1974–79 period. Tule perch appear to be extinct in the Pajaro, Salinas, and San Joaquin rivers, and are absent from many localities where they were previously collected in the early 1900's (Moyle 1976).

Moyle (1976) feels that this reduced range indicates a reduction in population abundance due to habitat changes in the Delta and tributaries, such as reduced flows, increased turbidity, heavy pollution, and reduced emergent and overhanging cover, which have reduced or impaired the quality of habitat. Recently, populations have become established in O'Neill Forebay of San Luis Reservoir, presumably due to water exports.

Sacramento Perch

Sacramento perch is the only native centrarchid west of the Rocky Mountains and inhabits sloughs, sluggish rivers, and lakes of the valley floor. Emergent aquatic vegetation serves as critical habitat for spawning and nursery grounds for young fish (Moyle 1976). Even though adequate habitat exists in the Delta, the perch has been eliminated from the Sacramento–San Joaquin system probably as a result of competition from exotic species (Moyle 1976). Electrofishing surveys conducted in the Sacramento–San Joaquin Delta by DFG from 1980 to 1984 yeilded no Sacramento perch (Kolhorst pes. comm.). The Interagency Ecological Study Program (IESP) has been conducting monitoring surveys at temporary barrier locations to examine fish population impacts as a result of barrier placement. The IESP monitoring study has been using fyke traps, electroshocking, and gill nets to survey these sites and no Sacramento perch has been collected. The last collection of a Sacramento perch in the Sacramento–San Joaquin Delta was in Peytonia Slough in 1976 when four individuals were collected (Kohlhorst, personal communication).

Introduced Fishes

Three families of fishes dominate the Delta's introduced resident fish assemblage: Centrarchidae, Cyprinidae, and Ictaluridae. The centrarchid family is represented by the introduced black basses and various sunfishes (Table 3.14–1). Largemouth bass are the most abundant of the black basses in the Delta and are a popular sport fish. Largemouth bass are solitary carnivores whose adult diet consists mainly of fish and crayfish, along with a secondary amount of insects and larger species of zooplankton (Turner 1966; Moyle 1976).

Largemouth Bass

Largemouth bass spawn in spring when water temperatures rise above 14–16° C and continue to spawn through June at water temperatures up to 24° C (Moyle 1976). Nests are shallow depressions in sand and gravel at depths of o ne to two meters, near submerged objects in noncolonial aggregations (Moyle 1976).

Sunfish

The various sunfish species are also opportunistic carnivores, feeding on insects, aquatic crustaceans, snails, and clams (DFG 1978). Turner (1966) found *Corophium* and *Neomysis* important food items of warmouth and black crappie; *Corophium*, tendipedid larvae and pupae, and the isopod *Exosphaeroma* were important to bluegill. Moyle (1976) indicated *Corophium* and *Neomysis* are important to white and black crappie. Fish are also a component of their diet, but to a lesser extent than for largemouth bass (Turner 1966; Moyle 1976). They all spawn in shallow water during spring and summer when water temperatures reach 57 to 75° F. Their spawning behavior is roughly similar to that of largemouth bass; they build nests near submerged objects or aquatic vegetation (DFG 1987). Except for the warmouth, they tend to form nesting colonies. Their eggs are adhesive and sink, attaching to the substrate. After the young hatch, they are guarded by the male for a short period, after which they disperse to the shallows (Moyle 1976).

DFG studies have found that introduced species, the sunfishes in particular, are most abundant in the east Delta (DFG 1987). Turner (1966) caught the majority of black crappie, bluegill, and warmouth in the deadend sloughs of the northeast Delta, including Hog, Sycamore, and Indian sloughs. Their abundance is correlated primarily with the deadend slough channel type and secondarily with the intermediate salinities and water clarity characteristic of the east Delta (DFG 1987). They were also abundant in oxbows, channels behind berm islands, and small embayments. This implies a preference for calmer waters and riparian or aquatic vegetation characteristic of those areas (DFG 1987).

Cyprinids

The introduced cyprinids are golden shiner, goldfish, and carp. Carp is by far the most common. Golden shiners live primarily in sloughs and are associated with dense mats of aquatic vegetation. They will tolerate low sum mer oxygen levels and water temperatures as high as 35°C. They are typically found with introduced sunfish. Golden shiners are a schooling fish, staying mostly in littoral areas. Lengths can reach 20 cm (Moyle 19 76).

Golden Shiners

Golden shiners spawn from March through August. Exact timing is dependent on water temperatures, usually occurring at temperatures of 15–20° C. The adhesive eggs are deposited on submerged vegetation and bottom debris. The eggs hatch in four to five days, and the fry school in large numbers close to shore. Golden shiners are widely used as a bait fish (Moyle 1976).

Goldfish

Goldfish populations generally become established in warm, often oxygen poor water in areas with mild winters. They are best suited for sloughs containing heavy growths of aquatic vegetation where they feed mostly on algae. Goldfish may reach lengths of 41 cm, and may live 25–30 years. Spawning, in their home range, occurs at temperatures of 15–32° C, with the first spawn of the year in April or May (Moyle 1976).

Carp

Carp are very similar to goldfish in their life history and preferred habitats. These two species have even been known to hybridize. Although what appears to be spawning behavior has been seen in the Delta, juveniles less then 100–150 mm are extremely rare (DFG pers. comm.). Carp are very widespread in the Delta and are common even in the major open channels (Don Stevens pers. comm.).

Ictalurids (Catfish)

The third major group of introduced species is the ictalurid or catfish family. White catfish, the most abundant, are more than 35 times as abundant, on average, as any other catfish species in the Delta. White catfish are carnivorous bottom feeders, consuming aquatic crustaceans, mollusks, insects, and fish.

Amphipods and *Neomysis* are the most important food items for both juveniles and adults (Moyle 1976). White catfish spawn in June and July when water temperatures exceed 21° C (Turner 1966). The female uses her fins to fan out a shallow nest depression in the substrate, the breeding pair spawns, and the adhesive eggs settle and stick to each other, forming an egg mass. One or both parents guard the eggs and the newly hatched young for a few weeks until the young disperse in schools (DFG 1987).

White catfish were found to be the dominant resident species of the south Delta (DFG 1987). Their abundance

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in this area maybe due to their greater tolerance of brackish water with salinities up to 12 ppt (Moyle 1976). DFG (1987) and Turner (1966) found them to be somewhat less abundant in the central and east Delta, and least abundant, but still common, in the north and west Delta.

The white catfish population in the Delta has been estimated by a DFG tagging study at between 3 and 8 million (1978–1980, unpublished data). No information on abundance is available for white catfish prior to operation of the CVP and SWP; therefore, the effects of the projects on their abundance are difficult to determine. The current distribution of white catfish, however, approximates that found in the early 1960's before SWP exports began ; therefore, changes in flow patterns induced by export operations and recent local diversions apparently have not affected white catfish distribution.

Channel catfish and brown and black bullheads have similar food preferences, with the exception that channel catfish probably consume more crayfish, clams, and fish than the other species (DFG 1987).

Channel catfish prefer the main channels of large streams (Moyle 1976). They were caught most often in areas of fast water in rivers and channels upstream from the central Delta, and were not taken in the west Delta (Turner 1966). Channel catfish nest in log jams or undercut banks; in ponds they will use old barrels or similar sites (Moyle 1976). Spawning occurs at temperatures of 21–29° C (Moyle 1976).

Brown and black bullheads were commonly found in the back of deadend sloughs of the Delta and were not taken in the west Delta (Turner 1966). Brown bullheads are much more common and wide spread in California because they can adapt to a wider variety of habitats (Moyle 1976). Social and breeding behavior of both species are similar. Adults school and are most active at night (Moyle 1976). Nest building and rearing are similar to that descr ibed for white catfish.

Recreational Use

The principal resident gamefish of the Delta, sunfishes, catfish, and bass, support an important recreational fishery and are, respectively, the second, third, and fourth most commonly caught groups of gamefish in the State. White catfish are the resident gamefish most often caught in the Delta. Largemouth bass are a major gamefish throughout the State, and in recent years large bass fishing tournaments have been organized in the Delta; 33 major tournaments and numerous smaller ones were held during 1989 (DFG, unpublished data). The harvest rate for bass in the Delta (about 30 percent) is somewhat lower than in fresh water reservoirs (50 percent), but it is still substantial, indicating the existence of an important and thriving largemouth bass sport fishery.

Although they are not commonly sought by anglers, the nongamefish of the Delta still fulfill important roles. Some serve as forage for gamefish, while others compete with or prey on gamefish. Each of the resident nongamefish has intrinsic ecological value, but in general, detailed knowledge of their life histories, population dynamics, and role in the community ecology of the Delta is limited.

Environmental Consequences

DFG has recently completed a study of abundance, distribution, and habitat preferences of resident fish in the Delta (DFG 1987). The following findings of this study are relevant to an assessment of potential Georgiana Slough test barrier impacts:

- Riprap banks are favorable habitat for only a few of the less desirable resident fish species in the Delta.
- Instream vegetation is favorable for largemouth bass, white catfish, and redear sunfish, three of the most important recreational resident fishes.
- Transport and nontransport channels differ in their species assemblages. Whereas catfish and black crappie were among those fish abundant in nontransport channels, largemouth bass and redear sunfish were more abundant in transport channels.
- Deadend sloughs, oxbows, channels behind berm islands, and small embayments had the highest densities of fish and largest variety of species.

Together, these findings suggest that generally the most favorable condition for resident fish species in the Delta is a diverse environment consisting of a highly vegetated shoreline with ample backwater and shallow areas.

The placement of a barrier at the head of Georgiana Slough may affect Delta smelt populations in several ways:

1) It may alter a spawning migration pathway by not allowing Delta smelt to traverse from the channels of the Mokelumne River to the Sacramento River.

2) It may increase or decrease the amount of spawning area available to Delta smelt if they use Georgiana Slough to spawn.

3) Closure of Georgiana Slough may alter spawning activity in the central Delta by affecting tidal current and salinity levels in the Delta. Once larvae have hatched and start the downstream movement toward the entrapment zone, the effect of reverse flows could increase the rate of entrainment and loss of Delta smelt larvae at the SWP and CVP export facilities.

In summary, the effect of the test barrier on Delta smelt is unknown, but is not expected to significantly affect the Delta smelt population.

The potential impacts of a closure of both the Delta Cross Channel and Georgiana Slough on longfin smelt will depend heavily upon the export rate relative to outflow from east and south Delta tributaries. Longfin smelt larvae are very susceptible to entrainment at the export facilities unless they are transported downstream beyond their influence by high freshwater outflow (50–75 thousand cfs are probably necessary to transport larvae into Suisun Bay and farther downstream).

In low outflow years longfin larvae are not dispersed downstream and the nursery habitat for longfin smelt is located in or near the Delta. Closing the Delta Cross Channel and Georgiana Slough would probably benefit longfin spawned in the Sacramento River and adjacent sloughs using these areas as a nursery by reducing their chances of entrainment at the pumps; however, individuals in the interior or the south Delta would be at a higher risk of loss at the SWP and CVP export facilities.

The proposed test barrier could affect water temperature, turbidity, and dissolved oxygen as a result of altering flow patterns in the Delta. However, these effects cannot be predicted. Efforts to correlate the distribution of resident fish in the Delta to variations in temperature and dissolved oxygen have been inconclusive. This is probably because water temperatures and dissolved oxygen levels throughout the Delta are relatively uniform and within the tolerances of resident fishes.

On the other hand, changes in salinity distribution could temporarily change the relative abundance of resident fish species. For instance, white catfish abundance may decrease, while other species, such as black bass, may increase.

The proposed test barrier will likely reduce the level of entrainment of resident fish of the central and south Delta at the CVP and SWP export facilities. The groups of species that are likely to be the most vulnerable to impacts are catfish and threadfin shad. Other groups such as cetrarchids and tule perch are typically less vulnerable to entrainment.

Resident game and nongame fish will likely not be affected significantly by disorientation or impoundment associated with the barrier. Increased predation at the barrier could be a factor while the barrier is in place.

Construction of the test barrier is not expected to impact resident fish. With the barrrier in place, Georgiana Slough may become an ideal spawning area for resident fish, with sluggish moving water and submergent vegetation for spawning. However, when the barrier is removed midway through the spawning season, the eggs and developing larvae could be swept downstream and possibly entrained at the CVP and SWP export facilities. With the increase in reverse flows due to export pumping, the salvage of splittails at the facilities could increase.

Mitigation

No mitigation is required. However, monitoring is proposed as part of the project, and may help clarify project effects, and thus shed more light upon Delta smelt population dynamics.

3.15 Fishery Resources: Fish Food Supply

Affected Environment

Fishery resources of the estuary are supported by a food web consisting of phytoplankton (algae), invertebrates, vertebrates, and detritus. The food web is dynamic; one organism feeds on another, and one food source is replaced by another with changes in season and the abundance and distribution of the food supply. Conditions that affect abundance and distribution of one link in the food web can affect the entire food web.

The general food habits of most species of fish inhabiting the estuary are known, but in most cases very little is known about the relationships between food organism density or production and the growth and survival of individual fish species. Nevertheless, the abundance and distribution of food organisms is thought to be an important factor in determining the overall health of the fish community in the estuary.

In the Sacramento–San Joaquin Delta, daily and seasonal changes in fresh and sea water, tides, winds, and currents interact with the food web. The complex interaction of these factors with the food web is difficult to unders tand; hence, how the Georgiana Slough Test Barrier Project may impact food supplies is mainly unknown.

Although some animals can consume detritus, phytoplankton are the primary basis of the aquatic food

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web in the estuary. These tiny, usually microscopic, single-celled algae use energy from the sun to convert simple inorganic molecules such as carbon dioxide, nitrate, and phosphate into the sugars, proteins, and fats required by herbivores in the estuarine food web. Clams, oysters, worms, and, most important, zooplankton depend on phytoplankton for their food supply.

Phytoplankton abundance in the estuary is controlled principally by the amount of light and nutrients available to sustain growth and reproduction, and, conversely, the amount of grazing they experience. Delta outflow also influences the abundance of phytoplankton in the upper estuary through its effect on the position of the entrapment zone. When Delta outflows are sufficient to position the entrapment zone adjacent to the shallows of Suisun Bay, where a greater portion of the water column is sufficiently penetrated by sunlight, phytoplankton production is greater.

Delta outflow also influences phytoplankton abundance through its effect on benthic grazers. Until 1988, during extended periods of low Delta outflow, marine grazers, particularly the clam *Mya arenaria*, would become established in Suisun Bay, consuming a significant portion of the phytoplankton and reducing the food supply for zooplankton. During the current six-year drought, a newly introduced clam, *Potamocorbula*, has become established in Suisun Bay in very high densities, replacing *Mya arenaria*. This new clam is though to have greatly reduced phytoplankton and zooplankton densities in Suisun Bay during the past four years. This reduced food supply for larval striped bass appears to have significantly reduced their survival in 1989.

Phytoplankton, as determined by measuring chlorophyll A, has undergone a long-term decline. Recent IESP studies have indicated that chlorophyll A is the variable most often significantly related to variations in zooplank ton and *Neomysis* abundance, suggesting that declines are due to a reduction in food supply.

The abundance of phytoplankton is affected by many interacting factors, including light penetration, residence time, water temperature, salinities, nutrients, and grazing by invertebrates. Attempts have been made to develop mathematical models for evaluating phytoplankton levels in the Delta and Suisun Bay region. Each model calculation uses input describing interrelationships among the physical, chemical, and biological factors that affect phytoplankton. Some of these inputs are channel geometry, flow distribution, dispersive transport characteristics, water quality variables, waste discharges, biological kinetic parameters such as phytoplankton growth rates, and physical parameters. Currently, the models are not sufficiently well developed to predict changes from water project operation.

Zooplankton is a general name for small aquatic animals that constitute an essential food source for fish, especially young fish and small forage fish. Numerous invertebrate species of zooplankton, which drift in the water column or have limited swimming capacity and zoobenthos (animals living on or in the substrate) inhabit the estuary. Both are important as food for many fish, including the juveniles of many gamefish.

Generally, zooplankton feed heavily on phytoplankton and thus transfer the energy of primary production to higher trophic levels.

High crustacean zooplankton abundance (copepods and cladocerans) is associated with low salinities, high chlorophyll A (phytoplankton), and low net velocities in Delta channels. Copepods are also associated with high salinities. Zooplankton populations are highest during summer. The opossum shrimp, *Neomysis mercedis*, an important part of the estuary's food web, is a food of young striped bass. Normally, more than 60 percent of the *Neomysis* population of the estuary is found in the Suisun Bay area, with much of the remainder found in the west Delta.

Salinity is the primary regulator of the distribution of zooplankton species in the estuary. In the upper part of the estuary, there are both fresh water and estuarine zooplankton. The fresh water zooplankton fauna is dominated by the cladocerans, *Daphnia parvula* and *Bosmina longirostris*, and copepods of the genera *Diaptomus* and *Cyclops*. An introduced Chinese copepod, *Sinocalanus doerii*, appears to be a fresh water species that ranges into the entrapment zone.

The most important zooplankton species are the native copepods, *Eurytemora affinis*, *Acartia californensis*, and *A. clausi*. *Eurtemora* reach their greatest abundance in the entrapment zone and extend into fresh water, while the *Acartia* are most abundant downstream of the entrapment zone. The shrimp, *Neomysis mercedis*, is concentrated in the zone of surface salinities ranging from 1.2 to 4.6 ppt.

There has been a long-term decline in abundance of all native zooplankton in the upper estuary, with the exception of the copepod *Acartia* and the shrimp *Neomysis*. Three accidentally introduced Asian copepods have helped maintain total copepod populations, but one recently introduced species, *Sinocalanus*, may have detrimentally affected the abundance and distribution of *Eurytemora*, which is the principal food for the youngest striped bass and perhaps other larval fishes (Figure 3.15−1). *Pseudodiaptomus* is another recently introduced species.

Two amphipods, *Corophium stimsoni* and *Corophium spinicorne*, are important constituents of Delta zoobenthos. They are the principal food for sturgeon, white and channel catfish, tule perch, and small black crappie, and are al so the second most important food of young striped bass. Other abundant benthic organisms are the Asiatic clam, tendipedid larvae, oligochaete worms, and crayfish. All are eaten by Delta fish, but none is as important as *Corophium*.

Environmental Consequences

Of the many zooplankton species examined by the IESP all have their distribution affected by Delta outflow and its influence on the salinity gradient, but only *Neomysis* has its abundance affected. Analysis of zooplankton abundance in Old River indicates that abundance is unrelated to volume of export pumping at CVP and SWP export facilities. However, zooplankton abundance in the San Joaquin River at the mouth of Old River appears to be reduced by cross−Delta flow to the export facilities. Cross−Delta flows are thought to reduce zooplankton abundance by lowering residence times in Delta transport channels and diverting water with lower zooplankton densities into the central Delta.

The temporary change in Delta flow distribution by closing Georgiana Slough from February 1 through April 30 is not expected to significantly affect phytoplankton and zooplankton abundance. There will be a temporary local loss of benthic life at the barrier location, due to placement of fill on the channel bottom. After the barrier material is removed at the completion of the test benthic life is expected to recover quickly to normal levels by recolonization.

Mitigation

No mitigation is required.

3.16 Cultural Resources

Affected Environment

Introduction

A single prehistoric archaeological site, CA−Sac−329, exists in the near vicinity of the proposed barrier site. It is a significant resource, having been partially excavated in 1976. Its exact boundaries, however, are unknown.

This section details the methods and results of cultural resource studies within the proposed project area, and provides management recommendations concerning archaeological resources.

Federal and State laws mandate consideration of archaeological and historical resources in the planning process for public projects. The National Historic Preservation Act of 1966 directs federal agencies to assume responsibility for consideration of cultural

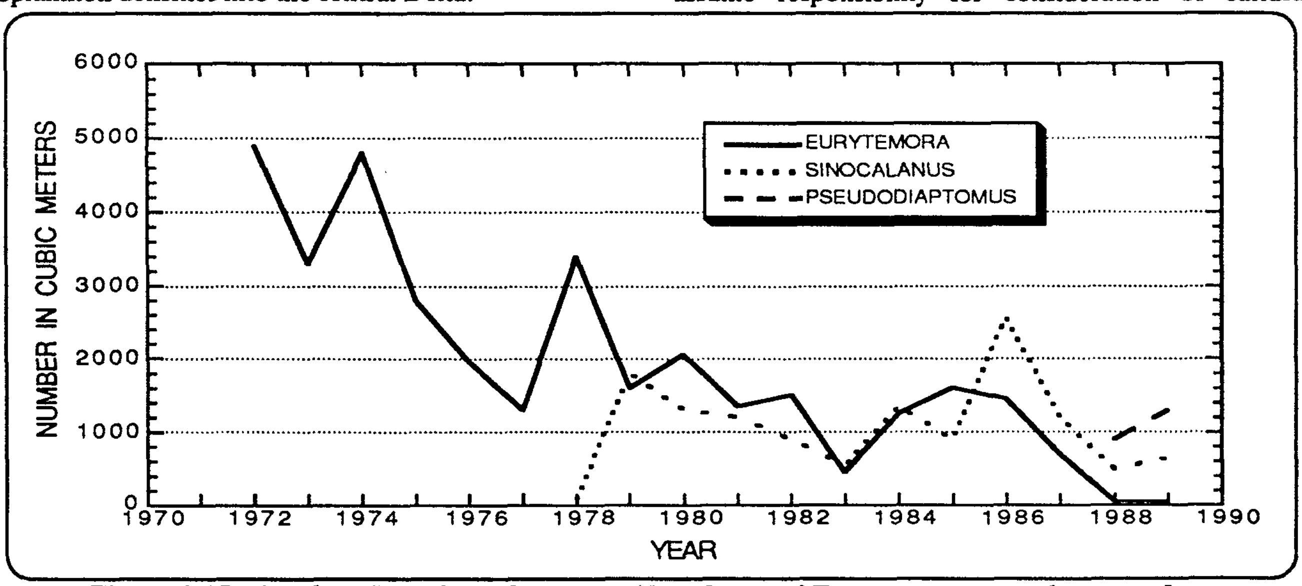

Figure 3.15−1. Mean March to November Abundance of *Eurytemora*, *Sinocalanus*, and *Pseudodiaptomus* from 1972 to 1989

resources. Section 106 of the Act requires the federal agency to consult with the State Historic Preservation Officer and the Federal Advisory Council on Historic Preservation (36 CFR 80 0). The California Environmental Quality Act of 1970 and the Guidelines for its Implementation provide for consideration of cultural resources in the planning process. In essence, these regulations require the sponsoring agency to identify any adverse effects on cultural resources resulting from their project, and propose means of reducing or eliminating these adverse effects.

The barrier project site is approximately one-half mile southwest of the community of Walnut Grove, California. It is situated in T. 5N, R 4E, the western one-half of Section 35 on the Isleton 7.5' USGS Quadrangle (1978). The site is reached by River Road or Isleton Road, which occupy the levee crests on either side of Georgiana Slough.

Three tentative locations for the proposed barrier have been investigated. The preferred location is north of the highway bridge crossing Georgiana Slough, very close to the mouth of the slough at its junction with the Sacramento River. The other two are south of the bridge a short distance. In order to insure adequate coverage of all three sites, this study was carried out in Georgiana Slough from the Sacramento River to "Mile 12" on the slough. This is south of the point where River Road departs the levee, approximately 550 meters below the mouth of the slough. This area would encompass all known alternative barrier sites under consideration (Figure 2-1).

Any significant cultural resources existing at the chosen barrier site may be imperiled by construction activities as well as the operation of a seasonal barrier.

Georgiana Slough is one of many channels and sloughs in the Sacramento-San Joaquin River Delta. It separates two large reclaimed tracts, Tyler Island and Andrus Island between the Sacramento River and North Fork Mokelumne River. Through its 12.5 mile length, it takes a twisted route through reclaimed farm lands, gas fields and pumping stations.

The present setting is a marked contrast with that prior to 1850 when large scale reclamation and dredging began to affect the vast network of tule marshes, rivers and sloughs in the delta. Levees, riprap construction, drains, pump stations, dredging and channel modification have produced the current network of islands and channels in the area. Most of the existing land, however, is at or below sea level, revealing its ancient heritage as a wetland marsh interspersed with dry plains.

Aboriginal vegetation in the Sacramento-San Joaquin Delta has been reconstructed from early accounts and pollen records (West 1977). Throughout most of the area plant life consisted of an extensive fresh water tule marsh that was constantly or seasonally flooded. Over this vast wetland, elevations rarely exceeded 25 feet above sea level. Therefore, the dominant vegetation was composed of tulles, cattails, sedges and willows. Along the rivers stood a vast riparian forest where natural levees supported dense stands of oak, cottonwood, willow, buckeye, ash and sycamore (Soule 1976:6). The dry plains, inundated only rarely, were dotted with solitary valley oaks. An extensive discussion of the environmental background can be found in West (1991).

Present vegetation at the project site is dominated by introduced species, although native plants can also be seen. This vegetative cover is described in the Vegetation and Wetlands section of this report.

The project area has been altered by levee and road construction. The Georgiana Slough highway bridge, a residence and boat docks and landings have also affected the original terrain. Much of the area ha s been armored by riprap rock from 6 to 18 inches in size. This rock protection often extends to the levee crest, although in most cases it is heavily overgrown by low vegetation. Some stretches of bank are not lined with rock. Here the original sediments can be seen where they have been exposed by wave erosion and undercutting.

The archaeological site identified in the vicinity of the proposed barrier was probably a slight natural rise above the river and marsh environment. Sediments are difficult to interpret at this locale, owing to deposition of dredged material and rock, but Soule's excavations revealed a pattern of cultural deposition interspersed with alluvial fill in the stratigraphic profile. He interpreted this as a seasonal prehistoric occupation of the low rise above the rivers in an area which was inundated during the winter and spring (1976:62).

Prehistoric Background

The Delta area of Central California has attracted archaeological interest for almost 100 years. Although some early antiquarians amassed vast artifact collections by digging into the mounds that were the homes of aboriginal peoples, not until the 1930s was the first systematic program of excavations in Central California carried out by students at Sacramento Junior College and

U.C. Berkeley. From this work, a cultural sequence for the California culture area was developed and refined based on stratigraphic location of distinctive artifact types of a time sensitive nature. This sequence, introduced by Lillard, Heizer and Fenenga in 1939, is still in use today, and while modified somewhat from its original formulation, has proven extremely useful in the chronological assignment of prehistoric sites for California and adjacent regions.

Three general time periods or horizons are recognized. The Early Horizon or Windmiller Period (dated approximately 2,500–500 B.C.) is known from a variety of sites in the Sacramento region. It is characterized by distinctive shell ornaments and charmstones, large projectile points with concave bases and stemmed points, baked clay balls used for cooking, fishing implements and grinding tools (Moratto 1984). Some researchers have suggested an even earlier occupation for the Delta region, but argued that evidence is buried beneath river alluvium or peat deposits (Waugh 1986 in Maniery 1989). The subsistence base of these villages is not entirely understood. Some evidence suggests that acorn processing was not significant during this time (West 1991:10).

Burials for the Early Horizon are distinctive. They are almost always extended, face down, containing red ochre, and oriented in a westward direction (Schulz 1970). These burials have typically been located in the lower levels of indurated sand mounds, and have been found by accidental exposure through agricultural activities. Little or no surface evidence is usually present (Maniery 1989:17).

The Middle Horizon period in the Delta spans from approximately 500 B.C to 300 A.D. Sites assigned to this era often overlie earlier deposits. They frequently contain substantial midden accumulation with shell, mammal and fish bone, charcoal, grinding implements, and distinctive obsidian blades. Greater complexity in social organization and trade networks is suggested in the variety and form of artifact assemblages. Disposal of the dead took the form of flexed as opposed to extended burial. During this period a great deal of region variation can be documented throughout California.

The time period from 300 A.D. to the arrival of Europeans is called the Late Horizon. It is marked by large village sites, dark "greasy" middens and occasional housepits. Subsistence is dominated by acorn and pine nut processing. A major technological innovation is the introduction of the bow and arrow (as demonstrated by small arrow points) whereas the atlatl had served as the primary hunting implement for many centuries. Deeply serrated obsidian points and curved blades are distinctive objects recovered from Late Horizon Delta deposits. Called "Stockton curves" they are thought to have been manufactured for ceremonial use, perhaps as bear claw depictions. Chisel–pointed pestles and an elaborate baked clay industry are also distinctive Late Horizon elements. Bone artifacts, including elaborate bird bone tubes and whistles give a glimpse of artistic expression. Basketry awls along with abalone ornaments are frequently found in these sites.

Cremation as a form of burial disposal becomes common in the Late Horizon. While found rarely during previous eras, it dominates mortuary custom during the Late Horizon. The appearance of clam shell disc beads is an important chronological trait. It has been argued that Phase II beginning about 1400 A.D. is defined by this artifact form and the exchange networks which extended throughout Central California to adjacent regions.

Ethnographic Background

The proposed Georgiana Slough test barrier project area was occupied by the Junizumne triblet of the Plains Miwok at the time of Euro–American contact. These Penutian speakers made their home over a vast area of the lower Sacramento Valley including sections of the Sacramento–San Joaquin Delta.

Incomplete documentation of Plains Miwok life occurred prior to the devastating impact of Spanish missionization, epidemic disease, and displacement from American populations. Even so, anthropologists have reconstructed a view of their society from aged informants, cultural traditions, and archaeological evidence. The following summary is derived extensively from that prepared by Soule (1976) for CA–Sac–329.

Plains Miwok groups were organized into triblet centers, usually dominated by a central village with a number of satellites. Their population density was perhaps the highest in Central California. Baumhoff calculated it to be 11 persons per square mile (1963:220), but since virtually all their activities were concentrated within one–half mile of rivers and streams, the effective density was more like 57 persons per square mile. This compares favorably with that of agricultural peoples in North America, attesting to the productivity of the Delta regions in Central California and to the efficiency of Plains Miwok culture.

Villages were situated along watercourses on natural points of higher ground. Structures consisted of conical houses made of tulles or grass thatch. Semi-subterranean lodges were also constructed, as were storage buildings and ceremonial roundhouses. Menstrual huts were a common feature in each village. Larger Miwok centers had populations resident year-round. As many as 500 to 1,500 people might occupy a single triblet center.

Subsistence activities centered around collecting plant foods, hunting, and fishing. Acorns were a significant dietary element, which could be stored for year-round use. These were supplemented with nuts (walnut and buckeyes), bulbs, seeds, berries and greens. Hunting and fishing were of secondary importance. Tule elk, mule deer, pronghorn antelope, rabbits, ground squirrels, and pocket gophers were commonly sought. Indications from faunal remains document the collection of frogs, turtles, salamanders, and waterfowl for food use. Important Delta fishes were salmon, sturgeon, chub, steelhead trout, sucker, squawfish, and splittail. Although anadromous fish runs so greatly impressed Europeans that other native fishes are rarely mentioned in historic accounts, faunal studies of archaeological deposits point to a greater prehistoric reliance on the latter than the former (Schulz and Simons 1973:110-112).

Utilitarian artifacts commonly recovered from Plains Miwok sites include baked clay net weights and cooking balls (since natural stone was a rare occurrence in the Delta), bone awls, bi-pointed fish hooks, antler flaking tools, fish harpoons, chipped stone projectile points, drills, knives and scrapers. Wooden implements, especially mortars and pestles were also common, but rarely survive archaeologically. Many forms of baskets, aprons, cradles and mats are also described. The tule balsa was the typical watercraft.

The economic base was developed to such an extent among the Plains Miwok that considerable time could be devoted to ceremonial activities and artistic expression. Ornamental objects were very elaborate. They included incised bird bone tubes, feathered head dresses, robes and elk tibia hair pins. Highly prised shell ornaments fashioned from abalone shell were also significant.

In Bennyhoff's extensive reconstruction of Plains Miwok geography, he notes that early accounts place the triblet center of Junizumne ("Unsumnes") at or near Walnut Grove, on the east bank of the Sacramento River. The population of this village is not precisely known, but mission records indicate a total of 3,000 for three triblets including the largest --Junizumne. No known archaeological deposit corresponds to this location. It may have been destroyed by early town and levee construction, or may exist at Sac-75, a short distance north. CA-Sac-329, recorded within the current project area, is also a possible candidate.

Extensive overviews of Plains Miwok culture have been prepared by Bennyhoff (1977) and Levy (1978). The serious reader is referred to them. Recent work by Siciliano-Kutchins has documented Miwok land use patterns in the north Delta region (1980) through interviews with surviving native families.

Historical Background

Historical use of the Delta region around Georgiana Slough has centered around reclamation, agriculture and recreation. During the period from 1860 to 1900, massive reclamation efforts were begun in the area. Chinese laborers, laid off from railroad construction, provided a ready work force to drain the wetlands, build levees and convert the peat soils to farmlands. The key to this conversion was the passage of the Swamp and Overflow Land Ac t of 1850. This transferred land ownership from the Federal government to the State and set the stage for private speculation and development.

Beginning in the late 1800's, dredging machinery was vastly improved to undertake the massive job of reclamation. Clam shell dredgers, hydraulic machines and steam dredges were brought in to scoop out river sediments and build permanent levees. This had been done earlier by hand labor using pilings, brush mattresses, drift logs and even derelict sailing ships filled with rock. These early levees presented many problems. Not only was the land very low lying to begin with (many acres at or below seal level), but the peat soils were subject to compaction, oxidation, and wind erosion once removed from their aqueous setting. Early levees needed constant repair. The yellow loamy clay formed on natural levees was used whenever possible, but peat soils were generally poor material for levee construction.

Even before levee building was entirely successful, farming began in the Delta. Asparagus, potatoes, beans and grains were grown in large quantities before 1900 (Maniery 1989:24). Onions, celery and lettuce were also grown for expanding markets in San Francisco, Sacramento, and Stockton. With agriculture came the development of landings from which to transport machinery, seed, and produce. This resulted in a steady increase in historic Delta population. Many of these farmers were Chinese and later Japanese immigrants. They became increasingly prominent, with George

Shima, a Japanese farmer, finally becoming known as the "Potato King" of the Sacramento–San Joaquin Delta (Maniery 1989:23).

Soule (1976:20) reports that Andrus Island was completely encompassed by levees as early as 1872–73, but floods frequently breached them during the following several decades. This early reclamation attempt may have placed fill over the original midden deposit along a contour between the existing levee and Sacramento River. Yellow river silts and sand were dumped in the site by clamshell dredges, producing an artificial stratigraphic layering.

Thorough summaries of Delta history have been prepared by Patterson et al. (1978) and Waugh (1986) They cannot be repeated here.. A recent historical resources overview has also been done by Owens (1991).

Pre–Field Investigations

A complete records search for the overall North Delta Program study area was performed by the North Central Information Center of the California Archaeological Inventory. All official site maps and archives were consulted as were the standard published references –– National Register of Historic Places Listed properties and Determined Eligible Properties – 1990 and updates, California Inventory of Historic Resources (1976), California Points of Historical Interest (1987 and updates), California Historical Landmarks (1990 and updates), Gold Districts of California (1979), California Gold Camps (1975), California Place Names (1969) and Historic Spots in Californi a (1966) (1990), Survey of Surveys (1989), CALTRANS Local Bridge Survey (1989), Shipwreck Data Inventory by the State Lands Commission (1989) and Early California Northern Edition (1974).

The records search revealed no recorded historic sites or shipwrecks known within the project area, although the Delta region is rich in such sites. The Georgiana Slough bridge has been evaluated by CALTRANS as a Number 5 –– Not Eligible for listing on the National Register of Historic Places.

The only known resource of significance within this project area is the Late Horizon prehistoric site designated as CA–Sac–329. It was recorded by Jerry Johnson and Patti Johnson during their 1974 reconnaissance of the Sacramento River drainage. The site is described as a large black midden covered by sandy silt with two distinct silt layers bisecting the deposit. Midden levels were measured at 135 cm and 140 cm in thickness. The visible area at the time is given as 45 meters, although riprap prevented accurate mapping.

CA–Sac–329 was being extensively eroded in 1974. Exposed artifacts were seen in abundance including baked clay balls, fire–affected rock, animal bones, basalt scrapers and a quartzite paint mortar.

As a result of erosion taking place of the deposit, Soule was commissioned to carry out excavations at CA–Sac–329 as part of a Corps of Engineers bank protection project. His extensive report (1976) allows for a reasonable assessment of the deposit. He concluded that one original cultural level had survived at CA–Sac–329, not the two postulated by Johnson. In the area he sampled, Soule was convinced that levee building had mixed river silts with midden soils producing an artifact bearing upper zone that produced no intact features. The lower deposit, by contrast, was marked by cooking features an intact primary cremation and an immature coyote burial.

Field Survey Methods

The proposed Georgiana Slough test barrier project area was closely inspected by John Foster, Senior State Archaeologist, in July 1992. A total of 4 person days were expended in surveying the complete river bank, levee and slough areas.

Standard archaeological methods were employed over the terrestrial areas. Repeated transects through the parcel were walked in a regular pattern. Spacing on the gentle lands was designed not to exceed 2 meters. All exposed soils were closely inspected. Steeper areas along the levees were covered as well as access and vegetation would permit. Special attention was paid to the CA–Sac–329 area where exposed silts could be seen. A review of the interior levee was also made in an attempt to distinguish cultural features.

The Georgiana Slough and stream banks were examined by boat. This consisted of a shallow water incursion among the vegetation in order to view as much of the exposed levee or bank as possible as well at any shipwrecks, landing remains or artifacts deposited in the water.

All evidence of prehistoric and historic activity was sought after in the field survey. This included midden soils, flaked stone tools and tool debris, ground stone tools, fire–affected rock, housepits, shell and bone food remains, clay balls, and rock alignments. Historic evidence such as foundations, pier pilings, structures, dumps, pits, ditches, mounds, cemeteries, exotic vegetation, ship remains and artifact concentrations were subject t o inquiry.

Navigation was not a problem during the survey. Levee roads and drainages form recognizable landmarks within the project area. Bridges and structures also mark boundaries. Detailed topographic maps allowed accurate positioning for the purpose of the survey. Dense riparian vegetation does obscure much of the terrain. Wild grape and blackberries grow through the riprap. Native soils were exposed by trowel wherever possible.

Survey Results

The proposed Georgiana Slough Test Barrier Project area yielded no surface evidence of additional archaeological or historic sites. The following features were noted and evaluated:

1. Pier Pilings: In two locations along the eastern bank of Georgiana Slough, a series of pier pilings is exposed in shallow water. They protrude through the silt parallel to the river bank on four foot centers. No connecting timbers are present. No fastenings or artifacts appear in association. They are probably the remains of residential docks of recent construction. They are not significant.

2. Georgiana Slough Highway Bridge: This two lane concrete and steel structure spans the slough in the center of this project area. It swivels on a massive concrete column in the center of the channel. An operational control building is set on the western terminus. This bridge has been evaluated by cultural resources experts in Caltrans, who found it not historically or architecturally significant.

3. CA–Sac–329: On the basis of present knowledge, this site consists of a Late Horizon midden deposit with intact features and human burials. It is located in the vicinity of the proposed barrier. The site boundaries can only be estimated on the basis of present information. Soule's 1976 report documented a deep cultural deposit along the Sacramento River, but Johnson's previous observations noted erosion of artifact bearing deposits by the flows through Georgiana Slough as well. Levee fill and riprap protection make exact boundary determinations problematic at the present time.

Sparse surface indications of archaeological potential can be seen in the vicinity of the site. Some dark sandy soil is visible, but the area is heavily used. No artifacts, shell or bone refuse, human burials or prehistoric features were seen. Therefore, no new information on the areal dimensions was collected from this study.

In spite of this lack of new information, the significance of any remaining deposits at CA–Sac–329 can be postulated from existing data. The site is extremely rich and important to our understanding of Plains Miwok culture during the Late Horizon. It is potentially eligible for listing in the national Register of Historic Places (36 CFR 60.6 [48 R 46306]) in category (d): It has "yielded or may be likely to yield, information important in prehistory or history."

The integrity of CA–Sac–329 may be called into question in this heavily used area. A levee road, underground telephone cable, riprap on channel banks, and recreational use have all imposed impacts in the general vicinity. Much of these same conditions prevailed when the site was test excavated in 1974, however, so it is reasonable to assume a significant cultural deposit may still exist at this location.

Environmental Consequences

Construction involving earth moving and heavy equipment could potentially damage archeological resources identified in this study.

Mitigation

It is strongly recommended that levee and stream bank sections in the vicinity of CA–Sac–329 be protected from any impact in the placement and construction of the proposed barrier. This can be accomplished by strict adherence to the following provisions:

1. No excavations should be made of any kind within the potential archaeological site area. Any such subsurface disturbance may imperil significant cultural deposits including human burials. Design of the barrier, if it is to be constructed in the vicinity, should involve the use of clean fill and rock. No removal of levee soil or any other excavation should be carried out.

2. All construction activity should be done from barges in Georgiana Slough. This will protect cultural deposits from compaction by heavy equipment that might be needed to place rock in the channel. A layer of additional riprap protection along key areas of the bank will help protect the remaining cultural deposits from erosion or

vandalism. This is a potential positive benefit of constructing a barrier at the proposed location.

3. If archaeological materials are uncovered in the course of project construction, all work should be halted in the vicinity of the finds and a professional archaeologist brought into evaluate the discovery and provide management recommendations concerning the protection of cultural resources. This is an important responsibility as the remaining deposits from CA–Sac–329 constitute a valuable heritage resource for the people of California.

3.17 Comparison Summary of Environmental Consequences and Mitigation

The proposed project, its potential environmental consequences, and mitigation measures have been analyzed in this Initial Study. In addition, the alternative and supplemental actions described in Section 2 have been analyzed. The environmental consequences and mitigation measures of these alternative and supplemental actions are summarized in Tables 3.17–1 through 3.17–7.

Table 3.17–1. Georgiana Slough Test Barrier, Comparison Summary of Environmental Impacts

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?			X
b. Disruptions, displacements, compaction,or overcovering of the soil?			X
c. Changes in topography or ground surface relief features?			X
d. Destruction, covering, or modification of any unique geologic or physical feature?			X
e. Any increase in wind or water erosion of soil, either on or off the site?			X
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?		X	
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?			X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?			X
b. The creation of objectionable odors?			X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?			X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?		X	
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X
c. Alterations to the course or flow of flood waters?			X
d. Change in the amount of surface water in any water body?		X	
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?		X	
f. Alteration of the direction or flow rate of ground water?			X
g. Change in the quantity of ground waters, either through direct additions or withdrawal, or through interception of an aquifer by cuts or excavations?			X
h.Substantial reduction in the amount of water otherwise available for public water supplies?			X
i. Exposure of people or property to water–related hazards such as flooding or tidal waves?			X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?			X
b. Reduction of the number of any unique, rare or endangered species of plants?			X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?			X
d. Reduction in acreage of any agricultural crop?			X

Table 3.17−1. Georgiana Slough Test Barrier, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
5. Animal Life. Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?			X
b. Reduction in the number of any unique, rare, or endangered species of animals?			X
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?			X
d. Deterioration of existing fish or wildlife habitat?			X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?		X	
b. Exposure of people to severe noise levels?			X
7. Light & Glare. Will new light and glare occur?		X	
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?			X
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?			X
b. Substantial depletion of any nonrenewable resource?			X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?		X	
b. Possible interference with an emergency response plan or an emergency evacuation plan?			X
11. **Population.** Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
12. **Housing.** Will the proposal affect existing housing or create a demand for additional housing?			X
13. **Transportation/Circulation.** Will the proposal:			
a. generate substantial additional vehicular movement?		X	
b. affect existing parking facilities or demand for new parking?			X
c. Substantially impact existing transportation systems?			X
d. Alter present patterns of circulation or movement of people and/or goods?		X	
e. Alter waterborne, rail, or air traffic?		X	
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?			X
14. **Public Services.** Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a.Fire protection?			X
b.Police protection?			X
c.Schools?			X
d.Parks or other recreational facilities?			X
e.Maintenance of public facilities, including roads?		X	
f.Other governmental services?			X

Table 3.17–1. Georgiana Slough Test Barrier, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
15. Energy. Will the proposal result in:			
a. Use of substantial amounts of fuel or energy?			X
b. Substantial increase in demand on existing sources of energy, or require development of new energy sources?			X
16. Utilities. Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a. Power or natural gas?			X
b. Communications systems?			X
c. Water?		X	
d. Sewer or septic tanks?			X
e. Storm water damage?			X
f. Solid waste and disposal?			X
17. Human Health. Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?			X
b. Exposure of people to potential health hazards?			X
18. Aesthetics. Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?			X
19. Recreation. Will the proposal affect the quality or quantity of existing recreational opportunities?		X	
20. Cultural Resources. Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?			X
b. result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?			X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?			X
d. restrict existing religious or sacred uses within the potential impact area?			X
21. Mandatory Findings of Significance.			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangeredplant or animal, or eliminate important examples of the major periods of California history or prehistory?			X
b. Does the project have the potential to achieve short–term—to the disadvantage of long–term environmental goals? (A short–term environmental impact is one that occurs in a relatively brief, definitive period, whereas long–term impacts will endure well into the future.)			X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)			X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?			X

Comparison Summary of Environmental Impacts

3.17–1. Georgiana Slough Test Barrier Project

A. Explanations for Responses of "Yes" or "Maybe"

Item	Impact Description
1f.	Siltation around the barrier might occur.
3a.	The barrier will prevent water from flowing into Georgiana Slough from the Sacramento River. However, two culvert pipes will allow water to flow into Georgiana Slough. The south end of Georgiana Slough will still be open to allow tidal fluctuations from the Mokelumne River.
3d.	The amount of surface water flowing into Georgiana Slough will reduce the stage in Georgiana up to one foot. This is well within the tidal range.
3e.	Water quality may diminish in Georgiana Slough as a result of reduced water flowing down from the Sacramento River.
6a.	Noise may increase during the construction of the barrier, if the barrier needs to be removed during a flood event, and during the barrier removal. However, changes in noise level are most likely insignificant.
6b.	Noise may increase during the construction of the barrier, if the barrier needs to be removed during a flood event, and during the barrier removal. However, changes in noise level are most likely insignificant.
7.	Lights will be seen on buoy and on the barge used to hoist boats over the barrier. These lights serve as warning and safety lights.
10a.	With the crane mounted on a barge, there is a potential for oil spilling and fuel spilling from the barge into the river, or slough.
13a.	Since all construction work will be done from a barge, it is not certain that the number of ve hicles in the area during construction will be a substantial addition.
13d.	Between the time construction begins (mid–January) and the time the barrier is removed (April). there is little boat activity in Georgiana Slough. In addition,the project has provisions to lift small boats over the barrier with a crane mounted on a barge.
13e.	As stated above, the barrier may slightly impact waterborne traffic.
14e.	Additional levee work will be done prior to installing the barrier to prevent erosion.
16c.	Water will be impacted for users of Georgiana Slough water. Additional pumping will be required as a result of lowering of the stage.
19.	Fishing in Georgiana Slough and boating through the slough will be impacted when the barrier is installed.
21a.	The project, which incorporates appropriate mitigation measures, will have no significant impact on the environment.

B. Explanations For Selected "No" Responses

Item	Impact Description
1e.	Water erosion of soil will be avoided by placing rip rap along the levee walls and along the channel bottom downstream of the barrier.
3c.	Alterations to the course or flow of flood flows will not be a factor since the barrier is designed to erode in the event of a flood.
20.	Cultural Resources will be preserved by not installing a boat ramp and relocating the barrier downstream from a culturally significant area.

Table 3.17–2. **Predation Control in Clifton Court Forebay, Comparison Summary of Environmental Impacts**

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?			X
b. Disruptions, displacements, compaction,or overcovering of the soil?		X	
c. Changes in topography or ground surface relief features?		X	
d. Destruction, covering, or modification of any unique geologic or physical feature?			X
e. Any increase in wind or water erosion of soil, either on or off the site?			X
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?			X
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?			X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?			X
b. The creation of objectionable odors?			X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?			X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?		X	
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X
c. Alterations to the course or flow of flood waters?			X
d. Change in the amount of surface water in any water body?			X
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?			X
f. Alteration of the direction or flow rate of ground water?			X
g. Change in the quantity of ground waters, either through direct additions or withdrawal, or through interception of an aquifer by cuts or excavations?			X
h.Substantial reduction in the amount of water otherwise available for public water supplies?			X
i. Exposure of people or property to water–related hazards such as flooding or tidal waves?			X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?		X	
b. Reduction of the number of any unique, rare or endangered species of plants?			X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?			X
d. Reduction in acreage of any agricultural crop?		X	

Table 3.17–2. Predation Control in Clifton Court Forebay, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
5. Animal Life. Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?			X
b. Reduction in the number of any unique, rare, or endangered species of animals?			X
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?			X
d. Deterioration of existing fish or wildlife habitat?			X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?			X
b. Exposure of people to severe noise levels?			X
7. Light & Glare. Will new light and glare occur?			X
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?			X
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?			X
b. Substantial depletion of any nonrenewable resource?			X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?			X
b. Possible interference with an emergency response plan or an emergency evacuation plan?			X
11. **Population.** Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
12. **Housing.** Will the proposal affect existing housing or create a demand for additional housing?			X
13. **Transportation/Circulation.** Will the proposal:			
a. generate substantial additional vehicular movement?			X
b. affect existing parking facilities or demand for new parking?			X
c. Substantially impact existing transportation systems?			X
d. Alter present patterns of circulation or movement of people and/or goods?			X
e. Alter waterborne, rail, or air traffic?			X
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?			X
14. **Public Services.** Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a.Fire protection?			X
b.Police protection?			X
c.Schools?			X
d.Parks or other recreational facilities?			X
e.Maintenance of public facilities, including roads?			X
f.Other governmental services?			X

Table 3.17–2. Predation Control in Clifton Court Forebay, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
15. **Energy.** Will the proposal result in:			X
a. Use of substantial amounts of fuel or energy?			X
b. Substantial increase in demand on existing sources of energy, or require development of new energy sources?			X
16. **Utilities.** Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a. Power or natural gas?			X
b. Communications systems?			X
c. Water?			X
d. Sewer or septic tanks?			X
e. Storm water damage?			X
f. Solid waste and disposal?			X
17. **Human Health.** Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?			X
b. Exposure of people to potential health hazards?			X
18. **Aesthetics.** Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?			X
19. **Recreation.** Will the proposal affect the quality or quantity of existing recreational opportunities?			X
20. **Cultural Resources.** Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?			X
b. result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?			X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?			X
d. restrict existing religious or sacred uses within the potential impact area?			X
21. **Mandatory Findings of Significance.**			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangeredplant or animal, or eliminate important examples of the major periods of California history or prehistory?			X
b. Does the project have the potential to achieve short–term—to the disadvantage of long–term environmental goals? (A short–term environmental impact is one that occurs in a relatively brief, definitive period, whereas long–term impacts will endure well into the future.)			X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)			X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?			X

Comparison Summary of Environmental Impacts

3.17–2. Predation Control at Clifton Court Forebay

A. Explanations for Responses of "Yes" or "Maybe"

Item	Impact Description
1b.	Disruption of soil may occur if construction activities occur as a result of building a bypass from Clifton Court Forebay.
1c.	With construction of a bypass, possible excavation activities would change topography.
3a.	The course or direction of water would occur if a bypass around the forebay were constructed.
4a.	Potentially, construction could change the number of a given species of plants, if plants or vegetation need to be removed.
4d.	Depending on the location of a bypass, agricultural areas could be impacted.
6a.	Noise levels would increase during construction periods if a construction solution was attempted. However, with nonconstruction solutions like netting, noise levels would not be increased.

B. Explanations For Selected "No" Responses

Item	Impact Description
13a.	Construction traffic would not significantly increase if a construction solution were implemented. With nonconstruction solutions, traffic impact would also be negligible.
14e.	Road improvements would not likely be required even if a heavy construction program were initiated.

Table 3.17–3. Reducing Fish Entrainment in Twitchell Island Agricultural Irrigation Siphons, Comparison Summary of Environmental Impacts

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?			X
b. Disruptions, displacements, compaction,or overcovering of the soil?			X
c. Changes in topography or ground surface relief features?			X
d. Destruction, covering, or modification of any unique geologic or physical feature?			X
e. Any increase in wind or water erosion of soil, either on or off the site?			X
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?			X
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?			X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?			X
b. The creation of objectionable odors?			X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?			X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?			X
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X
c. Alterations to the course or flow of flood waters?			X
d. Change in the amount of surface water in any water body?			X
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?			X
f. Alteration of the direction or flow rate of ground water?			X
g. Change in the quantity of ground waters, either through direct additions or withdrawal, or through interception of an aquifer by cuts or excavations?			X
h.Substantial reduction in the amount of water otherwise available for public water supplies?			X
i. Exposure of people or property to water–related hazards such as flooding or tidal waves?			X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?			X
b. Reduction of the number of any unique, rare or endangered species of plants?			X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?			X
d. Reduction in acreage of any agricultural crop?			X

Table 3.17–3. Reducing Fish Entrainment in Twitchell Island Agricultural Irrigation Siphons, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
5. Animal Life. Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?			X
b. Reduction in the number of any unique, rare, or endangered species of animals?			X
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?			X
d. Deterioration of existing fish or wildlife habitat?			X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?			X
b. Exposure of people to severe noise levels?			X
7. Light & Glare. Will new light and glare occur?			X
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?			X
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?			X
b. Substantial depletion of any nonrenewable resource?			X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?			X
b. Possible interference with an emergency response plan or an emergency evacuation plan?			X
11. **Population.** Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
12. **Housing.** Will the proposal affect existing housing or create a demand for additional housing?			X
13. **Transportation/Circulation.** Will the proposal:			
a. generate substantial additional vehicular movement?			X
b. affect existing parking facilities or demand for new parking?			X
c. Substantially impact existing transportation systems?			X
d. Alter present patterns of circulation or movement of people and/or goods?			X
e. Alter waterborne, rail, or air traffic?			X
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?			X
14. **Public Services.** Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a.Fire protection?			X
b.Police protection?			X
c.Schools?			X
d.Parks or other recreational facilities?			X
e.Maintenance of public facilities, including roads?			X
f.Other governmental services?			X

Table 3.17–3. Reducing Fish Entrainment in Twitchell Island Agricultural Irrigation Siphons, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
15. **Energy.** Will the proposal result in:			
a.Use of substantial amounts of fuel or energy?			X
b.Substantial increase in demand on existing sources of energy, or require development of new energy sources?			X
16. **Utilities.** Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a.Power or natural gas?			X
b.Communications systems?			X
c.Water?			X
d. Sewer or septic tanks?			X
e. Storm water damage?			X
f. Solid waste and disposal?			X
17. **Human Health.** Will the proposal result in:			
a.Creation of any health hazard or potential health hazard (excluding mental health)?			X
b.Exposure of people to potential health hazards?			X
18. **Aesthetics.** Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?			X
19. **Recreation.** Will the proposal affect the quality or quantity of existing recreational opportunities?			X
20. **Cultural Resources.** Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?			X
b. result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?			X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?			X
d. restrict existing religious or sacred uses within the potential impact area?			X
21. **Mandatory Findings of Significance.**			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangeredplant or animal, or eliminate important examples of the major periods of California history or prehistory?			X
b. Does the project have the potential to achieve short–term—to the disadvantage of long–term environmental goals? (A short–term environmental impact is one that occurs in a relatively brief, definitive period, whereas long–term impacts will endure well into the future.)			X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)			X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?			X

3.17—3. Reducing Fish Entrainment in Twitchell Island Agricultural Irrigation Syphons

A. Explanations for responses of "Yes" or "Maybe"

Item **Impact Description**

None

B. Explanations For Selected "No" Responses

Item **Impact Description**

All explanations received a "no" response for this alternative.

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Table 3.17–4. Testing Acoustic Fish Screen Techniques at the Entrance to Georgiana Slough, Comparison Summary of Environmental Impacts

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?			X
b. Disruptions, displacements, compaction,or overcovering of the soil?			X
c. Changes in topography or ground surface relief features?			X
d. Destruction, covering, or modification of any unique geologic or physical feature?			X
e. Any increase in wind or water erosion of soil, either on or off the site?			X
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?			X
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?			X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?			X
b. The creation of objectionable odors?			X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?			X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?			X
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X
c. Alterations to the course or flow of flood waters?			X
d. Change in the amount of surface water in any water body?			X
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?			X
f. Alteration of the direction or flow rate of ground water?			X
g. Change in the quantity of ground waters, either through direct additions or withdrawal, or through interception of an aquifer by cuts or excavations?			X
h.Substantial reduction in the amount of water otherwise available for public water supplies?			X
i. Exposure of people or property to water–related hazards such as flooding or tidal waves?			X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?			X
b. Reduction of the number of any unique, rare or endangered species of plants?			X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?			X
d. Reduction in acreage of any agricultural crop?			X

Table 3.17–4. Testing Acoustic Fish Screen Techniques at the Entrance to Georgiana Slough, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
5. Animal Life. Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?			X
b. Reduction in the number of any unique, rare, or endangered species of animals?			X
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?			X
d. Deterioration of existing fish or wildlife habitat?			X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?			X
b. Exposure of people to severe noise levels?			X
7. Light & Glare. Will new light and glare occur?			X
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?			X
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?			X
b. Substantial depletion of any nonrenewable resource?			X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?			X
b. Possible interference with an emergency response plan or an emergency evacuation plan?			X
11. Population. Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
12. Housing. Will the proposal affect existing housing or create a demand for additional housing?			X
13. Transportation/Circulation. Will the proposal:			
a. generate substantial additional vehicular movement?			X
b. affect existing parking facilities or demand for new parking?			X
c. Substantially impact existing transportation systems?			X
d. Alter present patterns of circulation or movement of people and/or goods?			X
e. Alter waterborne, rail, or air traffic?			X
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?			X
14. Public Services. Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a.Fire protection?			X
b.Police protection?			X
c.Schools?			X
d.Parks or other recreational facilities?			X
e.Maintenance of public facilities, including roads?			X
f.Other governmental services?			X

Table 3.17–4. Testing Acoustic Fish Screen Techniques at the Entrance to Georgiana Slough, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
15. Energy. Will the proposal result in:			
a. Use of substantial amounts of fuel or energy?			X
b. Substantial increase in demand on existing sources of energy, or require development of new energy sources?			X
16. Utilities. Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a. Power or natural gas?			X
b. Communications systems?			X
c. Water?			X
d. Sewer or septic tanks?			X
e. Storm water damage?			X
f. Solid waste and disposal?			X
17. Human Health. Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?			X
b. Exposure of people to potential health hazards?			X
18. Aesthetics. Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?			X
19. Recreation. Will the proposal affect the quality or quantity of existing recreational opportunities?			X
20. Cultural Resources. Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?			X
b. result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?			X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?			X
d. restrict existing religious or sacred uses within the potential impact area?			X
21. Mandatory Findings of Significance.			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangeredplant or animal, or eliminate important examples of the major periods of California history or prehistory?			X
b. Does the project have the potential to achieve short–term—to the disadvantage of long–term environmental goals? (A short–term environmental impact is one that occurs in a relatively brief, definitive period, whereas long–term impacts will endure well into the future.)			X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)			X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?			X

Comparison Summary of Environmental Impacts

3.17–4. Testing Acoustical Fish Screens at the Entrance to Georgiana Slough

A. Explanations for Responses of "Yes" or "Maybe"

Item	Impact Description
None	

B. Explanations For Selected "No" Responses

Item	Impact Description
6a.	The noise under the water surface would increase; however, this noise would not be audible on land.
20.	Cultural resources will not be impacted since this alternative would not require that any work be done in the sensitive areas near Georgiana Slough.

Table 3.17-5. Testing Barging of Hatchery Reared Winter Run Smolts, Comparison Summary of Environmental Impacts

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?			X
b. Disruptions, displacements, compaction,or overcovering of the soil?			X
c. Changes in topography or ground surface relief features?			X
d. Destruction, covering, or modification of any unique geologic or physical feature?			X
e. Any increase in wind or water erosion of soil, either on or off the site?			X
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?			X
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?			X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?			X
b. The creation of objectionable odors?			X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?			X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?			X
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X
c. Alterations to the course or flow of flood waters?			X
d. Change in the amount of surface water in any water body?			X
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?			X
f. Alteration of the direction or flow rate of ground water?			X
g. Change in the quantity of ground waters, either through direct additions or withdrawal, or through interception of an aquifer by cuts or excavations?			X
h.Substantial reduction in the amount of water otherwise available for public water supplies?			X
i. Exposure of people or property to water-related hazards such as flooding or tidal waves?			X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?			X
b. Reduction of the number of any unique, rare or endangered species of plants?			X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?			X
d. Reduction in acreage of any agricultural crop?			X

Table 3.17–5. Testing Barging of Hatchery Reared Winter Run Smolts, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
5. Animal Life. Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?			X
b. Reduction in the number of any unique, rare, or endangered species of animals?			X
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?			X
d. Deterioration of existing fish or wildlife habitat?			X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?			X
b. Exposure of people to severe noise levels?			X
7. Light & Glare. Will new light and glare occur?			X
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?			X
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?			X
b. Substantial depletion of any nonrenewable resource?			X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?			X
b. Possible interference with an emergency response plan or an emergency evacuation plan?			X
11. **Population.** Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
12. **Housing.** Will the proposal affect existing housing or create a demand for additional housing?			X
13. **Transportation/Circulation.** Will the proposal:			
a. generate substantial additional vehicular movement?			X
b. affect existing parking facilities or demand for new parking?			X
c. Substantially impact existing transportation systems?			X
d. Alter present patterns of circulation or movement of people and/or goods?			X
e. Alter waterborne, rail, or air traffic?			X
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?			X
14. **Public Services.** Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a.Fire protection?			X
b.Police protection?			X
c.Schools?			X
d.Parks or other recreational facilities?			X
e.Maintenance of public facilities, including roads?			X
f.Other governmental services?			X

Table 3.17–5. Testing Barging of Hatchery Reared Winter Run Smolts, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
15. **Energy.** Will the proposal result in:			
a. Use of substantial amounts of fuel or energy?			X
b. Substantial increase in demand on existing sources of energy, or require development of new energy sources?			X
16. **Utilities.** Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a. Power or natural gas?			X
b. Communications systems?			X
c. Water?			X
d. Sewer or septic tanks?			X
e. Storm water damage?			X
f. Solid waste and disposal?			X
17. **Human Health.** Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?			X
b. Exposure of people to potential health hazards?			X
18. **Aesthetics.** Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?			X
19. **Recreation.** Will the proposal affect the quality or quantity of existing recreational opportunities?			X
20. **Cultural Resources.** Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?			X
b. result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?			X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?			X
d. restrict existing religious or sacred uses within the potential impact area?			X
21. **Mandatory Findings of Significance.**			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangeredplant or animal, or eliminate important examples of the major periods of California history or prehistory?			X
b. Does the project have the potential to achieve short–term—to the disadvantage of long–term environmental goals? (A short–term environmental impact is one that occurs in a relatively brief, definitive period, whereas long–term impacts will endure well into the future.)			X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)			X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?			X

Comparison Summary of Environmental Impacts

3.17–5. Testing Barging of Hatchery Reared Winter Run Smolts

A. Explanations for Responses of "Yes" or "Maybe"

Item **Impact Description**

None

B. Explanations For Selected "No" Responses

Item **Impact Description**

All explanations received a "no" response.

Table 3.17–6. Testing Diverters to Guide Migrating Smolts, Comparison Summary of Environmental Impacts

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?			X
b. Disruptions, displacements, compaction,or overcovering of the soil?			X
c. Changes in topography or ground surface relief features?			X
d. Destruction, covering, or modification of any unique geologic or physical feature?			X
e. Any increase in wind or water erosion of soil, either on or off the site?		X	
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?		X	
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?			X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?			X
b. The creation of objectionable odors?			X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?			X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?		X	
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X
c. Alterations to the course or flow of flood waters?		X	
d. Change in the amount of surface water in any water body?		X	
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?			X
f. Alteration of the direction or flow rate of ground water?			X
g. Change in the quantity of ground waters, either through direct additions or withdrawal, or through interception of an aquifer by cuts or excavations?			X
h.Substantial reduction in the amount of water otherwise available for public water supplies?			X
i. Exposure of people or property to water–related hazards such as flooding or tidal waves?			X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?			X
b. Reduction of the number of any unique, rare or endangered species of plants?			X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?			X
d. Reduction in acreage of any agricultural crop?			X

Table 3.17–6. Testing Diverters to Guide Migrating Smolts, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
5. Animal Life. Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?			X
b. Reduction in the number of any unique, rare, or endangered species of animals?			X
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?			X
d. Deterioration of existing fish or wildlife habitat?			X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?		X	
b. Exposure of people to severe noise levels?			X
7. Light & Glare. Will new light and glare occur?			X
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?			X
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?			X
b. Substantial depletion of any nonrenewable resource?			X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?			X
b. Possible interference with an emergency response plan or an emergency evacuation plan?			X
11. Population. Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
12. Housing. Will the proposal affect existing housing or create a demand for additional housing?			X
13. Transportation/Circulation. Will the proposal:			
a. generate substantial additional vehicular movement?			X
b. affect existing parking facilities or demand for new parking?			X
c. Substantially impact existing transportation systems?			X
d. Alter present patterns of circulation or movement of people and/or goods?			X
e. Alter waterborne, rail, or air traffic?			X
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?			X
14. Public Services. Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a.Fire protection?			X
b.Police protection?			X
c.Schools?			X
d.Parks or other recreational facilities?			X
e.Maintenance of public facilities, including roads?			X
f.Other governmental services?			X

Table 3.17–6. Testing Diverters to Guide Migrating Smolts, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
15. **Energy.** Will the proposal result in:			
a. Use of substantial amounts of fuel or energy?			X
b. Substantial increase in demand on existing sources of energy, or require development of new energy sources?			X
16. **Utilities.** Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a. Power or natural gas?			X
b. Communications systems?			X
c. Water?			X
d. Sewer or septic tanks?			X
e. Storm water damage?			X
f. Solid waste and disposal?			X
17. **Human Health.** Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?			X
b. Exposure of people to potential health hazards?			X
18. **Aesthetics.** Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?			X
19. **Recreation.** Will the proposal affect the quality or quantity of existing recreational opportunities?		X	
20. **Cultural Resources.** Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?			X
b. result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?			X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?			X
d. restrict existing religious or sacred uses within the potential impact area?			X
21. **Mandatory Findings of Significance.**			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangeredplant or animal, or eliminate important examples of the major periods of California history or prehistory?			X
b. Does the project have the potential to achieve short–term—to the disadvantage of long–term environmental goals? (A short–term environmental impact is one that occurs in a relatively brief, definitive period, whereas long–term impacts will endure well into the future.)			X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)			X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?			X

Comparison Summary of Environmental Impacts

3.17–6. Testing Diverters To Guide Migrating Smolts

A. Explanations for Responses of "Yes" or "Maybe"

Item	Impact Description
1e.	Since the hydraulic conditions in a channel could change, their is a potential for an increase in water erosion of soil. This could be mitigated using rip rap, waterside berms, vegetation, or other methods.
1f.	Because of changing hydraulics, increased siltation, erosion might occur.
3a.	Such diverters to some extent would affect the channel currents. However, the impact would be insignificant.
3c.	Such diverters to some extent would affect the coarse or flow of flood waters. However, the impact would be insignificant.
3d.	With increased flows, a channel might notice a slight change in water surface elevation.
6a.	An increase in noise levels may be noticed during the construction of a diverter facility.
19.	Recreation in the area may be inconvenienced with the addition of a deflector structure. However, boats would be able to pass through Georgiana Slough.

B. Explanations For Selected "No" Responses

Item	Impact Description
1b.	Since the deflector structure would be in the channel, it was felt that displacing soil would not be required.
20.	Cultural resources will not be impacted. Structure will be constructed in the water.

Table 3.17–7. Testing Diversion Into the Deep Water Ship Channel, Comparison Summary of Environmental Impacts

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?			X
b. Disruptions, displacements, compaction,or overcovering of the soil?			X
c. Changes in topography or ground surface relief features?			X
d. Destruction, covering, or modification of any unique geologic or physical feature?			X
e. Any increase in wind or water erosion of soil, either on or off the site?		X	
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?		X	
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?			X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?			X
b. The creation of objectionable odors?			X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?			X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?		X	
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X
c. Alterations to the course or flow of flood waters?		X	
d. Change in the amount of surface water in any water body?		X	
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?			X
f. Alteration of the direction or flow rate of ground water?			X
g. Change in the quantity of ground waters, either through direct additions or withdrawal, or through interception of an aquifer by cuts or excavations?			X
h.Substantial reduction in the amount of water otherwise available for public water supplies?			X
i. Exposure of people or property to water–related hazards such as flooding or tidal waves?			X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?			X
b. Reduction of the number of any unique, rare or endangered species of plants?			X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?			X
d. Reduction in acreage of any agricultural crop?			X

Table 3.17–7. Testing Diversion Into the Deep Water Ship Channel, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
5. Animal Life. Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?			X
b. Reduction in the number of any unique, rare, or endangered species of animals?			X
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?			X
d. Deterioration of existing fish or wildlife habitat?			X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?		X	
b. Exposure of people to severe noise levels?			X
7. Light & Glare. Will new light and glare occur?			X
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?			X
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?			X
b. Substantial depletion of any nonrenewable resource?			X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?			X
b. Possible interference with an emergency response plan or an emergency evacuation plan?			X
11. **Population.** Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
12. **Housing.** Will the proposal affect existing housing or create a demand for additional housing?			X
13. **Transportation/Circulation.** Will the proposal:			
a. generate substantial additional vehicular movement?		X	
b. affect existing parking facilities or demand for new parking?			X
c. Substantially impact existing transportation systems?			X
d. Alter present patterns of circulation or movement of people and/or goods?			X
e. Alter waterborne, rail, or air traffic?			X
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?			X
14. **Public Services.** Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a.Fire protection?			X
b.Police protection?			X
c.Schools?			X
d.Parks or other recreational facilities?			X
e.Maintenance of public facilities, including roads?			X
f.Other governmental services?			X

Table 3.17–7. Testing Diversion Into the Deep Water Ship Channel, Comparison Summary of Environmental Impacts (Continued)

Comparison Summary of Environmental Impacts			
Environmental Impact	**Yes**	**Maybe**	**No**
15. **Energy.** Will the proposal result in:			
a. Use of substantial amounts of fuel or energy?			X
b. Substantial increase in demand on existing sources of energy, or require development of new energy sources?			X
16. **Utilities.** Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a. Power or natural gas?			X
b. Communications systems?			X
c. Water?			X
d. Sewer or septic tanks?			X
e. Storm water damage?			X
f. Solid waste and disposal?			X
17. **Human Health.** Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?			X
b. Exposure of people to potential health hazards?			X
18. **Aesthetics.** Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?			X
19. **Recreation.** Will the proposal affect the quality or quantity of existing recreational opportunities?		X	
20. **Cultural Resources.** Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?			X
b. result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?			X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?			X
d. restrict existing religious or sacred uses within the potential impact area?			X
21. **Mandatory Findings of Significance.**			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangeredplant or animal, or eliminate important examples of the major periods of California history or prehistory?			X
b. Does the project have the potential to achieve short–term—to the disadvantage of long–term environmental goals? (A short–term environmental impact is one that occurs in a relatively brief, definitive period, whereas long–term impacts will endure well into the future.)			X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)			X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?			X

Comparison Summary of Environmental Impacts

3.17–7. Testing Diversion Into Deep Water Channel

A. Explanations for Responses of "Yes" or "Maybe"

Item	Impact Description
1e.	Since the hydraulic conditions in a channel could change, their is a potential for an increase in water erosion of soil. This could be mitigated using rip rap, waterside berms, vegetation, or other methods.
1f.	Because of changing hydraulics, increased siltation, erosion might occur.
3a.	Such diverters to some extent would affect the channel currents. However, the impact would be insignificant
3c.	The course of flood waters might change since some water would be diverted.
3d.	With increased flows, a channel may notice a change in water surface elevation.
6a.	An increase in noise levels would be noticed during the construction of a diverter facility.
13a.	During construction of such a facility, traffic might increase in the area surrounding the project.
19.	Recreation in the area might be inconvenienced by a deflector structure.

B. Explanations For Selected "No" Responses

Item	Impact Description
1b.	Since the deflector structure and the rubber barrier would be in the channel, it was felt that displacing soil would not be required.
20.	Cultural resources will not be impacted. Structure will be constructed in an already developed area.

Chapter 4. Consultation And Coordination

General

This project is being implemented pursuant to a conservation recommendation proposed by NMFS in its February 14, 1992, Biological Opinion to the Bureau of Reclamation and as a potential reasonable and prudent alternative to avoid jeopardy to the winter run chinook salmon under ongoing Endangered Species Act, Section 7 consultation. Extensive staff level and executive level coordination has taken place over the past year between the Department of Water Resources, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Department of Fish and Game regarding potential implementation of the Georgiana Slough Test Barrier Project.

In addition to this consultation, there has been extensive interagency and public consultation and coordination on the Georgiana Slough Test Barrier Project.

- A project description and implementation schedule was distributed to involved State and federal agencies on July 9, 1992.
- An interagency coordination meeting was held July 20, 1992 to elucidate key environmental and permit issues and concerns.
- A presentation was made before the Delta Advisory Planning Council (DAPC) on July 30, 1992. DAPC includes representatives from all Delta counties. The meeting was open to the public.
- Additional interagency coordination meetings were held on August 3 and August 17, 1992, to provide progress reports and further discuss key environmental concerns and mitigation measures.
- A public workshop is scheduled to be held in Isleton on September 16, 1992. The meeting is being widely advertised by public notice, press, and direct mail.

Other Coordination and Consultation

There was also coordination and consultation with involved agencies and interest groups on specific environmental and permit issues.

Permit applications or coordination documentation has been prepared for a Department of the Army Permit, a Section 401 Water Quality Certification, a Section 1601 Streambed Alteration Agreement, and coordination with the State Lands Commission regarding use of State lands. Other coordination activities are described below:

The U.S. Coast Guard, the U.S. Army Corps of Engineers, and a major Delta barge operator were contacted to discuss possible impacts on Navigation. A meeting was held with Isleton and Walnut Grove fire safety and Sacramento County Sheriff's Office staff to discuss public safety concerns.

On July 22, 23, and 24, 1992 Department staff contacted Delta marina operators, boaters, and residents to discuss the proposed test barrier placement and its potential impacts on boating. One marina operator in turn contacted boat–slip renters to solicit their opinions. The Sacramento County and San Joaquin County Sheriffs offices were also consulted. The results of this consultation are discussed in the impacts section of this report.

On July 27, 1992 staff from the Department of Water Resources, the Reclamation Board, and the U.S. Army Corps of Engineers Flood Control Project Management Branch met to discuss design and operational criteria which would prevent project flood impacts. Following this meeting, additional studies of the Sacramento River flood hydrology, local hydrodynamics, and barrier breach scenarios were conducted and discussed. The results of this consultation are being incorporated into the barrier design and operating criteria.

D-002321

Chapter 5. Monitoring Program

This Monitoring, Evaluation and Management Program is to be accomplished by DWR and DFG as a part of installation of the Georgiana Slough Test Barrier Project.

The Test Barrier Project will be regularly monitored to document and analyze any potential beneficial or adverse effects on fish such as chinook salmon, striped bass, Delta smelt, white catfish, American shad, Sacramento splittail, longfin smelt, a nd green sturgeon. Water quality, stages, and flows will also be monitored to evaluate both the local and regional effects of the test barrier. Monitoring will also help verify computer modeling runs conducted for this project and thus help improve understanding of Delta hydrodynamics.

DWR commits to the following Program:

Coordination

DWR shall coordinate preconstruction engineering, planning and proposed operations with DFG, Army Corps of Engineers, USFWS, EPA, and NMFS.

Fishery Resource Monitoring Plan

Fishery resources monitoring shall be conducted as described below. It is the intent to submit to the regulating agencies reports on components of the monitoring program as the data becomes available. The components will be compiled in to a final report of the fishery and water quality monitoring and evaluation. A draft report analyzing the studies included herein will be submitted to the Corps, EPA, USFWS, NMFS, and DFG by December 1, 1993. The report w ill include data and analysis from 1993.

The report shall include but not be limited to identifying and evaluating the relationships between studies, trends, additional data needs, problems encountered, and recommendations for project and/or study modification in the event that a new program is to be initiated in following years. In the event that modifications to the plan are necessary during implementation, the permittee shall contact the Army Corps, District Engineer. If the District Engineer, in consultation with the USFWS, NMFS, EPA, DWR, and DFG, determines that modification is necessary, DWR shall implement approved modifications or remove the structure.

It is intended that the Fishery Resource Monitoring Plan described below will be implemented for the duration of the Georgiana Slough Test Barrier Project. The results of the sampling may indicate the need for changes, in the event a new program is initiated. The need for and characteristics of these changes will be identified in the program report, due December 1, 1993. Any recommended changes will be made only after DWR consults with the Corps, EPA, USFWS, NMFS, and DFG.

The program elements described below are collectively intended to monitor for and assess the following:

1) Changes in the distribution and direct loss at the CVP and SWP export facilities of young striped bass, Delta smelt, winter run chinook salmon and other fish species due to barrier related changes in Delta hydrodynamic conditions.

2) Changes in the survival of fall–run chinook salmon smolts emigrating from the San Joaquin River drainage.

3) Changes in the characteristics of the resident fish community in areas where aquatic habitat has been influenced by barrier operations.

4) Impedance of the upstream migration of adult fishes, particularly fall–run chinook salmon, particularly the Sacramento River races of chinook salmon.

5) Predation on juvenile fishes at barrier sites due either to changes in predator densities or enhancement of conditions for predation.

6) Changes in survival of winter run chinook salmon smolts emigrating from the Sacramento River.

7) Changes in suitable striped bass spawning habitat in the west, central, and north Delta.

The sampling methods to achieve these will be developed cooperatively by DWR, DFG, NMFS, USFWS, and the Corps in accordance with accepted scientific methods, efficient use of available funds, and the specific requirements of this project.

Water Quality Monitoring Program

Agricultural drainage pumps discharge into Georgiana Slough at five sites. Areas drained by the pumps consist of peat based agricultural lands, sewage percolation ponds, and the community of Isleton. At the time of year of the project, the drains discharge water pumped to lower the land side water table, to remove storm runoff, and leachate from agricultural fields. The discharge is expected to be high in nutrients and organic matter. Pesticide and herbicide loading from agricultural activities, however, should not be heavy at this time of year.

The barrier is expected to be in place from February 1, 1993 to April 30, 1993. The seasonal conditions of low water and air temperatures, and low intensity sunlight during this time will minimize water quality problems associated with increased algal growth in the channel. The value of pre-project water quality data in detecting trends will be minimal because it will be taken in January, one of the least productive months of the year for algae in the project area.

Although tidal activity will continue in Georgiana Slough under the influence of the San Joaquin River system, the barrier will temporarily convert it into a dead end slough, although there will be little seepage through the barrier (10 to 20 cfs). The monitoring program will focus on detecting any trends in water quality that could be associated with the dead end condition.

Monitoring Plan

Purpose: To document possible trends in temperature, turbidity, nutrient levels, chlorophyll, dissolved oxygen, electrical conductivity, total dissolved solids, pH, pesticides, herbicides, BOD, coliform and phytoplankton species composition in the project area of the Georgiana Slough Barrier.

Sampling sites:

1. Sacramento River immediately upstream of the barrier,
2. Georgiana Slough immediately downstream of the barrier,
3. Georgiana Slough near Brunk Road, and
4. Georgiana Slough at the Mokelumne River.

Sampling frequency:

1. All parameters except BOD, coliform, pesticides, and herbicides at every site once a week from January 18, 1993 to May 15, 1993. The two surveys in January will provide preproject sampling information.
2. BOD, pesticides and herbicides will be sampled once a month at site 2.
3. An 18 hour diel survey for dissolved oxygen and water temperature will be done in mid-April at site 2.
4. Coliform will be sampled beginning in mid-March with the protocol described in Standard Methods.

Remediation: If fish kills occur, the DFG, ACOE, NMFS, and USFWS will be notified within 48 hours. If serious water quality problems develop, mitigations steps as discussed in section 3.6 will be implemented after appropriate interagency consultation.

Hydrodynamics

Purpose: To provide quantification of changes in north Delta hydraulics and salinity patterns caused by the Project to compare to model output.

Methods:

A) There are existing stage recorders at both ends of Georgiana Slough:

- Sacramento River at Walnut Grove, on the left bank just upstream from Georgiana Slough, and
- Georgiana Slough at Mokelumne River, on the right bank just upstream from the confluence with the Mokelumne River.

The stage data from these recorders will be monitored. In addition, continuous recording of water velocity, temperature, and electrical conductivity will be conducted at sites 3 and 4 for periods of one week or more at each site, but not necessarily simultaneously.

B) Measure flow, by tidal cycle measurements, at these same sites, to calibrate the continuous recording instrumentation (S-4 or equivalent)

C) Conduct hydrologic modeling of conditions occurring in the Delta during the period of barrier installation, using DWRDSM with the appropriate input data. Compare model results with field data and evaluate. The results of the evaluation will be included in the final monitoring report.

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Appendix A
Biological Resources in the North Delta Study Area

BIOLOGICAL RESOURCES

Plants

Surveys were conducted for five plant species designated as endangered or candidate by the USFWS, or endangered or rare by CDFG. These species included the Antioch Dunes evening-primrose, Suisun marsh aster, California hibiscus, Delta tule pea, and Mason's lilaeopsis. In addition, a federal candidate species, Sandford's arrowhead, was discovered in the project area during our surveys.

Methods

Background data, including taxonomic descriptions, habitat requirements, and flowering times of the six designated plant species, were obtained from published descriptions, CDFG's California Natural Diversity Data Base (CNDDB), and botanical field notes from previous surveys.

Field surveys for plant species of special concern were conducted at the following times: on August 25, 30, and 31, September 1 through 5, and October 5, 1987; on October 11 and 31, 1988; and from September 8 through 11, 1989. Intensive searches of islands within stream channels and the waterside of levees were conducted from a small boat. Areas of natural vegetation on the landward side of levees were located from aerial photographs (USACE 1979) and surveyed on foot or by car. Extensive areas, such as agricultural fields, were surveyed from appropriate vantage points with the aid of binoculars.

Common plants were identified in the field using Mason (1957) or Munz and Keck (1963). Plants not identified in the field were collected and identified later by examining herbarium sheets. Plant species lists were compiled for all homogeneous vegetation types (Appendix A). The locations of special-status plant species were mapped on U.S. Geological Survey (USGS) 7.5 minute topographic quadrangles, and CNDDB field survey forms were completed for each new population.

Antioch Dunes Evening-Primrose

Status - Antioch Dunes evening-primrose (*Oenothera deltoides* Torr. & Frem. ssp. *howellii* (Munz) W. Klein) is designated as endangered by the USFWS and CDFG.

Background - Antioch Dunes evening-primrose is a short-lived perennial herb with showy white flowers appearing in mid-summer. It is currently known to occur at only three locations: 1) Antioch Dunes, within the city limits of Antioch, Contra Costa County; 2) Brown's Island, Contra Costa County; and 3) Brannan Island State Recreation Area, Sacramento County. The nearest of these sites is about 10 miles from the project area.

Source: Sensitive Species Survey Report for the North Delta Water Management Project, Ecos, Inc., July 1990.

At these three sites, Antioch Dunes evening-primrose is found on sand dunes bordering the Sacramento River. Other dune sites in the Delta have been converted to agriculture or industrial uses, rendering the habitat unsuitable for Antioch Dunes evening-primrose. The plant's historic distribution is not known.

Results - No populations of Antioch Dunes evening-primrose were located in the North Delta project area. The only potential habitat identified was north of Lambert Road near the proposed route of the New Hope Cross Channel. This habitat was identified from aerial photographs and recent soil mapping that indicate the presence of naturally stabilized dunes which have given rise to the Tinnin Soil Series (loamy-sand surface textured soils) (Tugel 1986). While most of the adjacent dune-fields have been leveled and are under cultivation (Steele pers. comm.), an uncultivated area of two to three acres supports herbaceous upland vegetation. This area, which is about 0.8 mile north of Lambert Road and 0.4 mile east of Snodgrass Slough, serves as a high-ground storage area for farm equipment.

The likelihood of occurrence of Antioch Dunes evening-primrose at this site is probably low, since the habitat has been highly altered by farm activities. The owners of the property denied access to search for the plant (Jonson pers. comm.). The landowner did not think the plant would be found on his property, since the area is occasionally disked for weed control. He also felt that a plant such as Antioch Dunes evening-primrose would have attracted his attention, and he had no recollection of such a flower on his property.

Suisun Marsh Aster

Status - Suisun marsh aster (*Aster lentus* Greene = *Aster chilensis* Nees var. *lentus* (Greene) Jeps.) is designated as a Category 2 candidate species by the USFWS.

Background - Suisun marsh aster has been collected from tidal streams around San Pablo Bay, the Suisun Marsh of Solano County, and the western edge of the Sacramento/San Joaquin Delta. It is known to occur near Rio Vista, Sacramento County, (Martz pers. comm., CNDDB 1988), about 10 miles from the project area. The exact distribution of the plant is not known.

This perennial species occurs in dense vegetation and areas of stabilized substrate. It grows up to eight feet tall, is nearly hairless, and produces white to violet flowers through the months of June to November. Under a recent revision of the genus Aster (Allen 1988), the plant is regarded as a full species, though it is part of a polyploid complex and may intergrade with *A. chilensis, A. hesperius, and A. bracteolatus.*

Results - Little Potato and Little Connection Sloughs, and Burns Reach of the San Joaquin River, collectively contain 22 Suisun marsh aster plants. Six of the plants were mapped on instream islands and the remaining 16 plants were found growing above the rock revetment on the water side of levees (Appendix C-1). Plant colonies ranged in size from individual stems covering less than two square feet to clumps covering up to 25 square feet.

No other populations of Suisun marsh aster were found in the project area. While marsh edge and levee-bank habitat are present in other locations, construction and maintenance of levees and erosion of instream islands may have reduced the potential habitat for this plant.

Mason's Lilaeopsis

Status - Mason's lilaeopsis (*Lilaeopsis masonii* Math. & Const.) is designated as a Category 2 candidate species by the USFWS, and as rare by CDFG.

Background - Mason's lilaeopsis is an inconspicuous herbaceous perennial that grows on the exposed mud banks of instream islands and occasionally at the base of earthen levees. It is usually less than two inches in height, and often grows intermixed with plants of similar appearance. It occurs in the Napa River, Suisun Bay, and the Sacramento/San Joaquin Delta. It is now known to be more widespread than once thought. Mason's lilaeopsis is threatened in the western portions of its range by salt water intrusion, and elsewhere in the Delta by alteration and loss of habitat due to accelerated erosion and bank protection projects.

Under natural conditions, habitat for Mason's lilaeopsis was kept open by wave action on the windward sides of Delta islands. Little is known about the plant's ecology in relation to inundation regimes, colonization of mineral substrate, and tolerance of (or requirement for) disturbance.

Results - Nine populations of Mason's lilaeopsis were located and mapped in the North Delta project area. Six populations were mapped in Study Area 1 (Little Potato and Little Connection Sloughs). Five of these populations were found in Little Potato Slough, on instream island mud banks (Appendix C-1). One population was found in Burns Reach of the San Joaquin River at the western end of Little Venice Island (Appendix C-1).

Three populations of Mason's lilaeopsis were found in Study Area 5 (the North and South Forks of the Mokelumne River) (Appendices C-3 and C-4). One population of fewer than 50 plants was located on an island at the mouth of Hog Slough. This population was of small stature, low density, and without flowers, indicating that the site may be of low quality for Mason's lilaeopsis. The presence of emergent tufts of dwarf rush (*Eleocharis acicularis*) and many dead buttonwillow snags suggested an increasing level of inundation, perhaps due to subsidence.

Several islands in Hog Slough which appear both on the 1978 USGS New Hope 7.5 minute topographic quadrangle and the USACE Delta Atlas (1979), have all but disappeared, leaving standing snags of willow, buttonwillow, and cottonwood as the only remaining evidence of this instream island habitat. These observations suggest that the Hog Slough population of Mason's lilaeopsis is endangered by habitat alteration.

The second population of Mason's lilaeopsis in the South Fork was found on the western edge of a large willow, dogwood, and marsh-dominated island immediately north of the mouth of Sycamore Slough. The population is spread along the island's entire western bank covering as much as 160 square feet. Here Mason's lilaeopsis grew in association with several similar mudbank herbs; thus, the number of Mason's lilaeopsis plants at the site was difficult to determine. The plant occurred throughout the available habitat.

The eroded mudbanks at this site were exposed to strong westerly winds and wave action, as well as prop-wash from passing boats. Mason's lilaeopsis plants were found growing up to 15 inches above the high tide line, where wave action may serve to keep the shallow-rooted mudbank species watered while removing the seeds and seedlings of competing species.

A third population was discovered on the tip of Staten Island at the confluence of the North and South Forks of the Mokelumne River. This population was intermixed with other mud bank plants.

Seemingly appropriate but uncolonized habitat for Mason's lilaeopsis was also found along the Mokelumne River between Interstate 5 and New Hope Landing (Study Area 3), and on islands at the northern end of Dead Horse Cut, in Snodgrass Slough, and in Lost Slough (Study Area 6). Colonization of these areas from downstream populations of Mason's lilaeopsis may not be possible because of the current entering Snodgrass Slough and the Mokelumne River from the Delta Cross Channel.

California Hibiscus

Status - California hibiscus (*Hibiscus californicus* Kell.) is designated as a Category 2 candidate species by USFWS.

Background - California hibiscus is a conspicuous perennial herb that produces large white flowers with red centers in late summer. It grows in well-developed freshwater marsh habitat along with dogwood, willows, tules, reeds, and other wetland species.

California hibiscus has been recorded from Central Valley marshlands from Butte County to San Joaquin County and the Delta. The range of California hibiscus has been diminished substantially by the channelization and draining of wetlands. In those portions of the Delta where high quality freshwater marsh habitat remains, the plant is not uncommon. The loss of remaining habitat is considered the primary threat to the species.

Results - California hibiscus was found at ten locations in the project area (Appendix C-4). Three sites were found in Little Potato Slough on the instream islands. One population was found in Little Connection Slough on an instream island, and one population was found on an island off the west end of Little Venice Island in Burns Reach of the San Joaquin River. A reported location for California hibiscus at the mouth of Hog Slough (USACE 1979) was searched for but the plant was not found. Several islands in this slough have been lost to erosion.

The greatest concentration of California hibiscus was found in the Snodgrass Slough area. Ten plants were found near the former railroad bridge site in DMSP, and 11 locations supporting between one and six plants each were found along Snodgrass Slough north of the old railroad bridge site. Three more plants were found on the south shore of the central island in the mouth of Lost Slough. On the South Fork of the Mokelumne River, California hibiscus was found on two instream islands upstream from the mouth of Hog Slough.

Delta Tule Pea

Status - Delta tule pea (*Lathyrus jepsonii* Greene spp. *jepsonii*) is designated as a Category 2 candidate species by the USFWS.

Background - Delta tule pea is a pink-to-lavender-flowered perennial vine that grows in tangled masses among tules and in marsh borders with willow and dogwood. This preference for wetland sites separates it from its closest relative, *L. j.* spp. *californicus*, a plant of drier upland settings. While the two subspecies generally are found in different habitats, intergradation is possible (Broich pers. comm.). Historically, Delta tule pea may have occurred throughout the wetlands of the Central Valley, but it now is known only from scattered locations near Palo Alto, Suisun Marsh, and the Delta. The nearest known populations are near White Slough, three miles south of Terminous (CNDDB 1988).

Results - Twelve populations of Delta tule pea were found in the project area (Appendices C-3 and C-4). Nine of these populations were found near Snodgrass Slough (Study Area 6). Populations ranged from isolated individual plants to patches covering 30 and 60 feet of streambank. Because of the plant's sprawling habit and the fact that it is often rooted beneath dense tangles of willow and bramble, the number of individuals at a given site could not be determined.

In Study Area 5, individual Delta tule pea plants were seen on two islands within the South Fork Mokelumne River between Beaver and Hog Sloughs. Each of these sites had one to three individuals covering 10 to 20 feet of bank. A single plant of Delta tule pea was also found on the instream islands in the North Fork Mokelumne River. This plant may have been comprised of several individuals which formed a tangle of vines over the dogwood and buttonwillow (Appendices C-3 and C-4).

Sanford's Arrowhead

Status - Sanford's arrowhead (*Sagittaria sanfordii* Greene) is designated as a Category 2 candidate species by USFWS.

Background - Sanford's arrowhead is an aquatic perennial herb that flowers from May through September. It is currently known from Butte, Fresno, Sacramento, and Del Norte Counties; it has been extirpated from Ventura County. This plant was once common in irrigation ditches but under modern conservative water management, its habitat has been diminished. The plant is very similar to a more common annual species and may be overlooked or misidentified during field surveys. The plant's rarity and endangerment are in need of further study.

Results - Sanford's arrowhead was discovered on a point bar in Steamboat Slough (Appendix C-2) and between two tule islands in the North Fork Mokelumne (Appendix C-3). The Steamboat Slough population consisted of only 10 plants while the population in the Mokelumne River was estimated in the thousands of individuals. These two locations represent range extensions for the currently known distribution of the species. The plant has not been recorded previously from the Delta.

Birds

Aleutian Canada Goose

Status - The Aleutian Canada goose (*Branta canadensis leucophareia*) is listed as endangered by the USFWS.

Background - This distinct race of the Canada goose breeds only on a few of the Aleutian Islands. The current population stands at about 5,300 individuals (Springer pers. comm.). The entire population winters in California, primarily at Grizzly Island in the western Delta, and near Modesto, Stanislaus County. The Delta region lies between these two wintering areas, and there have been numerous reports of small numbers of Aleutian Canada geese at scattered Delta locations in the 1970s and 1980s (Springer unpublished data). These locations have included Staten Island and Brack Tract in the project area. In these areas the geese are attracted to waste corn and young grain.

Methods - Species specialists species and local biologists were contacted regarding sightings. Roads in the project area were driven on December 12, 1987, January 14 and 22, 1988, and March 20, 1988. Binoculars were used to search the fields for flocks of geese. When Canada geese were located, a spotting scope was used to identify the subspecies.

Results - Although several small flocks of Canada geese of other races were seen, no Aleutian geese were found. No reports of Aleutian geese were received from the Delta in 1987-88, according to agency biologists concerned with the species (Springer pers. comm., Deuel pers. comm., Gifford pers. comm.).

Greater Sandhill Crane

Status - The greater sandhill crane (*Grus canadensis tabida*) is listed as threatened by CDFG.

Background - Birds of this subspecies are considerably larger than the more abundant lesser sandhill crane (*G. c. canadensis*). Greater sandhill cranes, which breed in scattered locations in British Columbia, eastern Washington, eastern and south-central Oregon, and northeastern California, migrate to wintering areas in the Central Valley of California. Known as the Central Valley population, this group of cranes numbers approximately 6,000 (Pogson and Lindstet 1988). Their most important wintering area is near Thornton, San Joaquin County, where two-thirds of the known population was found in January 1984 (Pogson and Lindstedt 1988). In this area the cranes forage on waste corn left in fields after the fall harvest. The cranes night roost on the Brack Tract at the Woodbridge Ecological Reserve, a 145-acre area recently purchased by CDFG (Schlorff pers. comm.) and on Staten Island (Pogson and Lindstet 1988).

Methods - Roads in the project area were driven on December 12, 1987; January 14 and 22, 1988, and March 20, 1988. Binoculars and a spotting scope were used to scan fields for cranes and to identify the subspecies.

Results - Greater sandhill cranes were found foraging throughout the project area, including Staten Island, New Hope Tract, Canal Ranch Tract, Brack Tract, and Terminous Tract. The most concentrated foraging use appeared to be on Canal Ranch Hope Tract within the area bounded by Peltier Road, Blossom Road, and Beaver Slough. Night roosting was observed at the Woodbridge Ecological Reserve.

During these observations, relatively few cranes were seen in areas which would be affected by the project. Cranes on Staten Island were concentrated along the western portion of the island. However, foraging areas probably change with annual variations in cropping patterns and rainfall.

Swainson's Hawk

Status - The Swainson's hawk (*Buteo swainsonii*) is listed as a threatened species by the CDFG. It was recently reclassified as a Category 3 candidate species by the USFWS.

Background - The Central Valley breeding range of the Swainson's hawk extends from Tehama County in the north to Tulare County in the south. The population is most dense in the center of this range, in Yolo, Sacramento, and San Joaquin Counties, where an approximate total of 120 nest sites have been located in the past 10 years (CDFG unpublished data). Scattered nesting sites are known in the Delta region, but much of this area has not been adequately surveyed (Estep pers. comm.).

There are several records of the species' occurrence in the North Delta region. Most records consist of observations of Swainson's hawks soaring or foraging (CNDDB 1989). CNDDB and CDFG records also include nests in the following locations: 1) in a cottonwood tree along Elk Slough, five miles north of Steamboat Slough, active in 1983; 2) near the Sacramento River, three miles northeast of Steamboat Slough, active in 1979 and 1980; 3) along the southern end of Steamboat Slough, four miles south of its confluence with Sutter Slough, active in 1983, and; 4) near Grizzly Slough, less than one mile east of the Mokelumne River, active in 1979.

Important habitat elements for Swainson's hawks include agricultural lands (especially alfalfa and grains) for foraging and suitable trees for nesting. Nesting habitat is limited in the Delta. Habitat occurs primarily within the severely diminished riparian woodland habitat type.

Methods - Field surveys for Swainson's hawks were conducted by boat on the Mokelumne River, the South Fork, and around Dead Horse Island on May 10, 1988, and by car and on foot in the McCormack-Williamson and Snodgrass Slough areas on May 19, 1988. Swainson's hawk surveys were conducted by car on levee roads along Steamboat, Sutter, and Georgiana Sloughs on June 7, 1989. The Mokelumne River from west of Interstate 5 (I-5) to Dry Creek was surveyed by boat on June 2, and on foot on June 7 and 30, 1989. The observer identified all raptors encountered and searched for nests in all trees of sufficient size.

Results - A check of the Swainson's hawk nest territory near the north end of Snodgrass Slough mentioned in the CNDDB report revealed that red-tailed hawks are currently nesting at that location. An active Swainson's hawk nest was found along Snodgrass Slough 0.6 mile north of Lambert Road. Swainson's hawks were also observed in apparent foraging behavior over DMSP and along the Mokelumne River above New Hope Landing. One Swainson's hawk nest was found near river-mile 25 along Steamboat Slough. The nest was located in a Cottonwood tree on the left bank. This territory was occupied again in the 1990 breeding season. The nest was located in a cottonwood tree at river-mile 24.9 and was found to be unsuccessful in 1990. (The nest was located during Swainson's hawk surveys for the Sacramento River Bank Protection Project, contracted by CDWR.)

Two Swainson's hawks were observed flying over the Mokelumne River and above agricultural fields to the north on June 7. One active raptor nest was located in a cottonwood tree on the river side of the Mokelumne River. No adult birds were observed on or near the nest, and the species of young in the nest could not be identified. However, it is likely that the nest was a Swainson's hawk nest. The nest site was visited again on June 30, but no birds were present in the area. (Locations of Swainson's hawks observations and nests are depicted in Appendices C-5 and C-6.)

Potential nesting trees (cottonwood and oak) were identified on both levees along Steamboat Slough. However, foraging habitat is limited on Sutter and Grand Islands which are predominately orchards. Several potential nesting trees occur along the east side of Georgiana Slough, within one mile downstream from the slough's confluence with the Sacramento.River. Potential nesting habitat occurs throughout the continuous riparian woodland along the Mokelumne River from I-5 to Dry Creek. In addition, agriculture in the adjacent fields (grains) provides foraging habitat for Swainson's hawks.

Nesting habitat which appears to be suitable for Swainson's hawks is absent from most of the South Fork Mokelumne and North Fork Mokelumne Rivers. According to DeHaven and Weinrich (1988), the project area contains a significant portion of the riparian woodland remaining in the Delta; therefore, the project area contains a significant portion of the available Swainson's hawk nesting habitat in the Delta.

California Black Rail

Status - The California black rail (*Laterallus jamaicensis coturniculus*) is designated as as threatened by the CDFG, and as a Category 2 candidate species by the USFWS.

Background - The California black rail formerly occurred in limited numbers in coastal salt marshes from Tomales Bay, Marin County, south to northern Baja California, Mexico (CDFG 1983). It also was found in inland freshwater marshes, including the Delta and lower portions of the Colorado River (CDFG 1983). Dawson (1923) described it as being of general occurrence in fresh- and saltwater marshes during migration, and common or sporadically abundant in the salt marsh tributaries of San Francisco and Tomales Bays.

Recently, occurrences of black rails in central California are most commonly recorded in marshes bordering San Pablo Bay and the Napa and Petaluma Rivers. This species is resident in California, and is much more widely distributed in winter than in summer (Grinnell and Miller 1944). Current population trends are unknown, but are suspected to be downward due to the loss of coastal and freshwater marshes (CDFG 1987).

Relatively little is known of the black rail's status in the Delta region (Evens pers. comm., Manolis pers. comm.). CNDDB records contain references to the species in the vicinity of the North Delta project area, such as Manolis' (1978) reported occurrence of black rails at White Slough, four miles east of Little Potato Slough. Other CNDDB records for black rails at White Slough were reported in May 1982 as two rails calling. In April and May 1988, black rails were heard by ECOS biologists along Middle River, approximately 10 miles southeast of the project area (ECOS 1989).

This species prefers tidal salt marshes dominated by heavy growths of pickleweed (*Salicornia* spp.) or bulrush (*Scirpus* spp.) (Grinnell and Miller 1944, Manolis 1978). High population densities were found in *Salicornia* marshes around San Francisco Bay in 1988 (Evens pers. comm.). However, only the bulrush/cattail (*Scirpus/Typha*) marsh habitat type is found in the project area, which until recently was not regarded as suitable for black rails (ECOS 1987).

Methods - Marsh habitat suitable for black rails was identified and mapped during reconnaissance surveys on May 10 and June 7, 1989 (Appendices C-7 and C-8). The most extensive bulrush/cattail marsh occurs in Little Potato and Little Connection Sloughs. The only other potential black rail habitat identified in the project area consisted of small areas of bulrush-dominated emergent vegetation along the North Fork Mokelumne River and around the emergent marsh islands on the South Fork Mokelumne River.

On May 23, 1988, taped black rail calls were played from a canoe during evening hours around the emergent marsh islands along the South Fork Mokelumne River. On June 2, 1989, taped black rail calls were played from a small boat during morning and late afternoon hours in the north end of Little Connection Slough and throughout Little Potato Slough. A total of 13 locations on six channel islands was surveyed using taped calls. On June 19, taped calls were played during evening hours (2015 - 2300 hours) while observers canoed around islands in the southern end of Little Connection Slough and around the eastern half of Venice Island. Calls were played at 12 locations. Marsh habitat mapped and surveyed is depicted in Appendix C-8.

Results - Two black rail responses were heard at one location in Little Potato Slough, at its confluence with White Slough (Appendices C-7 and C-8). The responses were heard on June 2, at 1005 hours and consisted of one set of the "kic-kic-keer" call and one "grrring" call. The calling rail was not actually observed, but was probably within 30 meters of the southeast end of Devil's Isle. The habitat along the southern end of the island is dominated by emergent bulrush and cattails in the tidal zone and by shrub and tree willow, cottonwood, and dogwood (*Salix* spp., *Populus fremontii,* and *Cornus stolonifera*) in upland areas. Suitable black rail habitat throughout the remainder of the project area is limited. The few areas of marsh vegetation are either growing from inundated substrates or are dominated by willows). No other responses were heard during our surveys.

Tricolored Blackbird

Status - The tricolored blackbird (*Agelaius tricolor*) is designated as a Category 2 candidate species by the USFWS.

Background - The breeding range of the tricolored blackbird formerly included the Central Valley and low foothills of the Sierra Nevada, from Shasta County south to Kern County, along the coast from Sonoma County to the Mexican border, and occasionally on the Modoc Plateau (Grinnell and .1iller 1944).

Tricolored blackbird populations have declined throughout California (USFWS 1985), although colonies continue to nest and winter in the Sacramento and San Joaquin Valleys, including the Delta region (Beedy pers. comm.). CNDDB records include a 1982 nesting colony about eight miles north of the Mokelumne River (Alternative 3). No comprehensive surveys have been conducted in recent years. Nesting colonies are usually located in emergent marsh, blackberry thickets, or fallow agricultural areas overgrown with mustard and may not be in the same locations from year to year. Roosting areas for large winter flocks typically are in extensive stands of marsh vegetation (Beedy pers. comm.).

Tricolored blackbirds typically nest in heavy growths of cattails and bulrush (*Typha* spp., *Scirpus* spp.); they may also use willow, thistle, mustard, blackberry, saltcedar, and wild rose for nesting sites (Grinnell and Miller 1944). In addition, proximity to productive foraging grounds is an important factor in nest site selection (USFWS 1985).

The decline of tricolored blackbird populations has probably been caused by the extensive loss of suitable wetland nesting habitat, nest disturbance, and the aerial spraying of herbicides and insecticides (Terres 1980, USFWS 1985). This species can be sensitive to disturbance; aerial spraying or repeated human entries into nesting colonies may result in nest abandonment (Hosea 1982, USFWS 1985).

Methods - The Mokelumne River from Interstate 5 to New Hope Landing, the Dead Horse Island area, and the South Fork from New Hope Landing to Terminous were surveyed for breeding blackbirds by boat on May 11, 1988. At irregular intervals observers climbed the levees and scanned agricultural lands with binoculars. The McCormack-Williamson Tract and the Snodgrass Slough area were surveyed by car and on foot on May 19, 1988.

Steamboat Slough, Georgiana Slough, the North Fork Mokelumne River, Little Potato Slough, and Little Connection Slough were surveyed for suitable tricolored blackbird habitat on May 10 and June 2, 1989. On June 2, 7, and 19, potential habitat associated with Study Areas 1, 2, 4, and 5 was surveyed for breeding blackbirds by boat and on foot.

To survey for wintering blackbirds, an observer drove public roads on Terminous Tract, Brack Tract, Canal Ranch Tract, New Hope Tract, and Staten Island on December 12, 1987; January 14 and 22, 1988; and March 20, 1988. Agricultural areas were scanned with binoculars and a spotting scope.

Results - No tricolored blackbirds were seen in the project area. Other blackbird species were observed throughout the area. Potential nesting habitat was found in marsh vegetation around Venice Island, along Little Connection and Little Potato Sloughs, on Tyler Island (west side of the North Fork Mokelumne River), and at a few locations along the North Fork Mokelumne River. Potential nesting habitat was also located in marsh vegetation on islands on the South Fork near Westgate Landing, Beaver Slough, Hog Slough, and Sycamore Slough, along Snodgrass Slough and Lost Slough, and in scattered blackberry thickets and fallow fields elsewhere. With the possible exception of Snodgrass Slough and Lost Slough, marsh vegetation is probably not extensive enough to support winter roosts. Potential wintering habitat occurs on New Hope Tract (along the south and landward side of the Mokelumne River), on several channel islands in Little Potato Slough, and around the partially submerged Venice Island at the south end of Little Connection Slough.

Reptiles and Amphibians

Methods

Surveys for special status reptile and amphibian species were conducted by walking, wading, and boating along marshes and waterways in the project area. A total of six days in 1989 (from April 1 through July 24, 1989), and eight days in 1988 (April 11, 25 and 26; May 20, 27, and 30; June 3; and September 8, 1988), were spent looking for giant garter snakes, western pond turtles, California tiger salamanders, and California red-legged frogs (Table 2). Potential basking sites along waterways and beneath boards and other debris deposited by floodwaters were searched. Because the activity and observability of reptiles and amphibians depends on temperature and weather, surveys were timed to correspond with optimal conditions for these special-status species.

Giant Garter Snake

Status - The giant garter snake (*Thamnophis couchi gigas*) is listed as a threatened species by the CDFG, and designated as a Category 2 candidate species by the USFWS.

Background - The giant garter snake formerly ranged throughout the floor of the Central Valley from the vicinity of Gridley in Butte County, southward to Buena Vista Lake in Kern County (Hansen and Brode 1980). Agricultural development has extirpated the giant garter snake from the southern San Joaquin Valley, and its present range extends from Fresno County north through the Central Valley (Hansen and Brode 1980). The giant garter snake is the most aquatic of California's lowland garter snakes, and is rarely seen more than a few feet from water (Fitch 1940). It frequents areas of permanent fresh water, particularly sloughs and marshes overgrown with tules and willows (Hansen and Brode 1980). This subspecies also can be found in temporary water such as flooded rice fields and irrigation canals.

Individuals can be found basking on stream banks or draped on emergent and streamside vegetation from March through October. The cool winter months are spent in dormancy, probably in cracks and burrows above the high water line (Hansen 1982). The giant garter snake forages along watercourses for fish and amphibians (Hansen 1982). The diurnal habits and shallow open water habitat of this species make it vulnerable to predators including egrets, herons, and northern harriers; consequently, it is a wary, secretive snake (Fitch 1940). Its wariness, and its tendency to take cover in water at the least disturbance, make it difficult to observe.

Table 2. **Timing of 1989 Reptile and Amphibian Surveys for the North Delta Project Area.**

DATE	AREA SURVEYED
4-1-89	Little Potato Slough and Little Connection Slough
4-8-89	Little Potato Slough and Little Connection Slough
4-9-89	Mokelumne River (E of I-5)
5-15-89	North Fork Mokelumne River
5-19-89	North Fork Mokelumne River
7-24-89	Dead Horse Island/Steamboat Slough

Activities associated with agricultural development, especially the draining of wetlands and channelization of rivers, are the primary factors responsible for the decline of the subspecies (Hansen and Brode 1980). Predation by introduced gamefish also may be a factor in its decline (Hansen personal observation).

Results - Only one giant garter snake was observed during our surveys; however, suitable habitat for this species was found at several sites within the project area. The snake, a large pregnant female, was found west of Snodgrass Slough about 0.75 mile NNE of Locke.

The following project features were surveyed for potential supporting habitat of the giant garter snake.

Little Potato Slough and Little Connection Slough - These large waterways contain islands supporting rich marsh vegetation similar to that known to support giant garter snakes in other locations. The levees are rip-rapped on the side adjoining the slough, and support little but annual grasses, especially on the landward side. These sloughs may function more as movement corridors for giant garter snakes than as supporting habitat.

The landward agricultural areas adjoining these sloughs (Bouldin Island and Venice Island on the west, Empire Tract on the east) contain ditches and canals which appear marginally suitable for giant garter snakes. One lake on Empire Tract (one mile north of Eight Mile Road) appears similar to giant garter snake habitat at Coldani's Marsh (Upland Canal) five miles to the east.

Sacramento River at Georgiana Slough - Although the banks of the Sacramento River support wetland vegetation, it is unlikely that giant garter snakes occur here since they apparently avoid large flowing waterways.

Mokelumne River - The levees of the Mokelumne River are vegetated and rip-rapped east of I-5 but appear less than suitable for giant garter snakes except as movement corridors. The landward side of the south levee presently supports grasses and other upland vegetation, while the adjacent land is devoted to cultivated crops and urban dwellings. Additionally, this area has been inundated by floodwaters as recently as February, 1986 (Hansen personal observation).

Steamboat Slough and Sutter Slough - Riparian woodlands and other vegetation were being removed along portions of this slough during the course of our surveys, leaving open banks interspersed with stretches of rip-rap. Other areas, especially in the north, retain their ash and oak woodlands. Conditions here appear marginally suitable for giant garter snakes.

North Fork and South Fork Mokelumne Rivers - The North Fork and South Fork and their rip-rapped levees are maintained in an open condition and appear unsuitable for giant garter snakes. However, small canals and drainage ditches along the landward side of the west levee and adjoining Tyler Island support stands of cattail, tule, and other wetland vegetation that may be suitable for giant garter snakes. Broad Slough and other canals intersecting the west levee on southern Tyler Island appear typical of giant garter snake habitats. The landward side of the east levee and adjoining Staten Island appear less suitable than the western, Tyler Island side, although agricultural ditches and canals there may be marginally suitable for giant garter snakes.

Dead Horse Island supports few ditches or canals suitable for giant garter snakes. In addition, the island was inundated during much of 1988 by floodwaters. The major waterways surrounding the island (North Fork Mokelumne, lower Snodgrass Slough, and Dead Horse Cut) and their levees also appear to represent only marginally suitable habitat for giant garter snakes. However, one giant garter snake was observed approximately 1.5 miles to the north during 1988 North Delta surveys (ECOS 1988), so it is possible that giant garter snakes utilize these waterways as well.

Museum and sight records of giant garter snakes within this general vicinity are summarized in Table 3. This species should be considered a possible inhabitant of waterways in the project area because of the availability of apparently suitable habitat, and records of nearby occurrences. It is our opinion that the lack of giant garter snake observations during the 1989 surveys could reflect this snake's wary, reclusive habits and low local densities rather than its absence from the project area.

Table 3. Known Localities of the Giant Garter Snake in the Project Vicinity Prior to 1989 Surveys.

Locality	County	Reference
Mormon Island	San Joaquin	Fitch 1940
Stockton, 5 miles N	San Joaquin	MVZ[1]
Eight Mile Road at WPRR, 3.5 miles W Hwy. 99	San Joaquin	CDFG
Antioch Bridge	Sacramento	UMMZ[2]
10 miles S Sacramento	Sacramento	Fitch 1940
Arno Rd., W side Hwy. 99	Sacramento	CDFG
Snodgrass Slough W. Elliot Road	Sacramento	CDFG
Franklin Blvd., 0.5 mile S Hood-Franklin Rd.	Sacramento	CDFG
0.4 mile N Elk Grove Blvd., W side Hwy 99	Sacramento	CDFG
0.5 mile S Sheldon Rd., 0.2 miles W Hwy 99	Sacramento	CDFG
Sheldon Rd., 0.3 mile W Bruceville Rd.	Sacramento	CDFG
Beach Lake Preserve, 1 mile S Freeport	Sacramento	CDFG
0.75 mile NNE Locke	Sacramento	ECOS 1988

[1] Museum of Vertebrate Zoology, University of California, Berkeley

[2] University of Michigan Museum of Zoology

Suitable habitat for the species was found throughout the project area, including Snodgrass Slough, Lost Slough, The Meadows Slough, DMSP, and on vegetated islands and banks along the Mokelumne River. Habitat was also found in drainage ditches and small sloughs amid agricultural lands in the area of Lambert and Twin Cities Roads; on the McCormack-Williamson, New Hope, Canal Ranch, Brack, and Terminous Tracts; and on Staten Island.

Due to the number of museum and sight records in this general vicinity and the widespread presence of highly suitable habitat, the giant garter snake should be considered an inhabitant of all waterways in the project area. It is our opinion that the limited number of observations during field surveys reflects this snake's wary, reclusive habits and low local densities, rather than its absence from the project area.

Western Pond Turtle

Status - The western pond turtle (*Clemmys marmorata*) is designated as a Category 2 candidate species by the USFWS.

Background - Western pond turtles occur throughout California west of the Cascade-Sierra crest (Stebbins 1972). They are associated with ponds and waterways in grasslands, oak woodland, and coniferous forests. This aquatic reptile inhabits marshes, creeks, and irrigation ditches that are lined with emergent vegetation (Stebbins 1985). They feed on aquatic plants, fish, invertebrates, and carrion (Stebbins 1972). Western pond turtles have declined due to the loss of aquatic habitat resulting from agricultural development, water diversions, stream channelization, and urbanization.

Results - Several large adult western pond turtles were observed during our field surveys in Lost Slough, Snodgrass Slough, and the South Fork Mokelumne River. Since no small turtles were observed, it is not known whether a viable breeding population exists in these areas. No other western pond turtles were observed during our field surveys.

California Tiger Salamander

Status - The California tiger salamander (*Ambystoma tigrinum californiense*) is designated as a Category 2 candidate species by the USFWS.

Background - This species inhabits grasslands and open woodlands of Central California from Sonoma to Santa Barbara County. California tiger salamanders breed in reservoirs, ponds, large temporary rain pools, lakes, and slow-flowing streams (Stebbins 1972). Adults emerge from underground terrestrial retreats with the onset of winter rains, and move to temporary and permanent bodies of water to breed from November through February (Stebbins 1985). Eggs are laid singly or in small clusters, and usually are attached to vegetation in shallow, calm water (Stebbins 1972). The eggs hatch into aquatic larvae, which mature into terrestrial adults by late May. At this time the metamorphosed salamanders join adults in surrounding terrestrial habitats. They usually spend the dry summer months underground in rodent burrows or other cool, moist retreats.

Results - No California tiger salamanders were observed during these surveys, nor was suitable supporting habitat found on the project area. While these salamanders do occupy vernal pools located north, east, and south of the project area, widespread and frequent inundation of this area has probably precluded their presence here.

California Red-Legged Frog

Status - The California red-legged frog (*Rana aurora draytoni*) is designated as a Category 2 candidate species by the USFWS.

Background - This species occurs in the north and south Coast Ranges, the Transverse Mountains, and on the western slope of the Cascades and Sierra Nevada (Stebbins 1972). It is absent from the floor of the Central Valley.

Red-legged frogs are found in moist woods, forest clearings, riparian vegetation, and grassland (Stebbins 1972). They seek quiet, permanent water where dense streamside vegetation provides adequate cover. This amphibian frequents ponds, pools along streams, springs, marshes, lakes, and reservoirs.

Results - No California red-legged frogs were observed during our surveys, nor was suitable supporting habitat found in the project area. Nearby occurrences are limited to mainland populations southwest of the project area in Contra Costa County.

Fish

Delta Smelt

Status - Populations of the Delta smelt (*Hypomesus transpacificus*) have recently shown serious declines (Herbold and Moyle 1987), and the USFWS Sacramento Endangered Species Office is recommending that the species be proposed as a Category 1 candidate (Kobetich pers. comm.).

Background - Unlike most fish species found in the Delta, the Delta smelt spends its entire life cycle in the Delta estuary (Moyle et. al 1986). Smelt are seldom found at salinities greater than 10 parts per trillion (ppt); the majority of the population lives at salinities of less than 2 ppt for most of the year, including during spawning activities (Ganssle in Moyle 1976).

This native fish schools in large numbers in Suisun and San Pablo Bays from September to November. Late in the fall, they begin to move up the river systems as far as Isleton on the Sacramento River, and Mossdale on the San Joaquin (Moyle 1976). Spawning occurs from December through April in channels and dead-end sloughs. After spawning, the adults and fry remain in the backwaters until late summer. Population declines are believed to be related to ecological changes in Suisun Bay (Moyle pers. comm.). Research on the species is continuing.

Methods - No field surveys were conducted for the Delta smelt; information on its distribution and occurrence was acquired from agency biologists and academic authorities.

Results - Little is known of this species' occurrence in the project area (Moyle pers. comm.). Suitable habitat may be present, but due to the large population decline this habitat may not be occupied. Delta smelt were not encountered during CDFG electrofishing studies in the Mokelumne River area in the early 1980s (Kohlhorst pers. comm.).

Sacramento Splittail

Status - The USFWS Sacramento Endangered Species Office is recommending that the Sacramento splittail (*Pogonichthys macrolepidotus*) be proposed as a candidate for Category 2 status due to population declines of the species over much of its range (Kobetich pers. comm.).

Background - This native minnow was formerly widely distributed in the streams and lakes of the Central Valley. Presently, its range is limited to the Sacramento/San Joaquin Delta. The species usually is found in the slower currents and is highly tolerant of brackish water (Moyle 1976). Splittail are found in Suisun Bay from February through April. Spawning occurs from March to May after they move upstream into dead-end sloughs. Splittail prefer to spawn in calm water, depositing their eggs over submerged vegetation (Moyle 1976).

Methods - No field surveys were conducted for this species. Information on occurrence was acquired from agency biologists and academic authorities.

Results - CDFG electrofishing surveys in 1981 found over 20 splittail in the Mokelumne River near the Interstate 5 bridge, indicating that the species probably spawns in that portion of the river. A few individuals also were found at scattered locations in the South Fork and Snodgrass Slough (Kohlhorst pers. comm.).

Sacramento Perch

Status - The USFWS Sacramento Endangered Species Office has recommended that the Sacramento perch (*Archoplites interruptus*) be placed on the Category 2 candidate list.

Background - This perch is the only member of the sunfish family native to California. It was formerly abundant in lowland waters throughout Central California, but has been greatly reduced by habitat loss and competition from introduced fishes (Moyle 1976). In the Delta, CDFG biologists regard the species as very rare and possibly extirpated (Kohlhorst pers. comm.).

Methods - No field surveys were conducted for this species. Information was sought from agency biologists and academic authorities.

Results - CDFG electrofishing studies in the Mokelumne River and South Fork in the early 1980s found no Sacramento perch, and the species has not been seen in the Delta since the 1970s (Kohlhorst pers. comm.). It is unlikely that the species occurs in the project area.

Insects

Sacramento Anthicid Beetle

Status - The Sacramento anthicid beetle (*Anthicus sacramento*) is classified by the USFWS as a Category 2 candidate species.

Background - The Sacramento anthicid beetle is a flightless, nocturnal microscavenger specific to the unstable environment of riverine sand dunes (Hagen 1986, Hagen pers. comm., Singleton no date). The loose, shifting sand of the dune serves as a substrate for the deposition of wind-blown pollen, spores, and dead insects. Larvae reportedly feed upon vegetable detritus and possibly soil fungi (Singleton no date).

The range of this beetle extends along the Sacramento River from the lower Sacramento Valley to the Delta region, but due to the beetle's specificity for dune habitat, its distribution is very restricted. The majority of collections have been reported from Brannan Island, Rio Vista, and Grand Island.

Methods - No specific surveys for the Sacramento anthicid beetle were undertaken; rather, during other survey efforts, observers conscious of habitat requirements watched for suitable habitat (riverine dunes).

Results - Analysis of aerial photographs and recent soil mapping identified two to three acres of remnant dune habitat north of Lambert Road, between Snodgrass Slough and the Southern Pacific Railroad grade. No other suitable habitat for the Sacramento anthicid beetle was identified during survey efforts.

Antioch Dune Beetle

Status - The Antioch dune beetle (*Anthicus antiochensis*) is classified by the USFWS as a Category 2 candidate species.

Background - This species is very similar in habit to the smaller Sacramento anthicid beetle. It is also a flightless, nocturnal microscavenger of riverine dunes (Hagen 1986, Hagen pers. comm.). The size differential is postulated to have restricted the distribution of the Antioch dune beetle by limiting its ability to inhabit smaller expanses of suitable habitat (Hagen 1986).

The Antioch dune beetle is believed to be restricted to two locations: the west end of Grand Island, Sacramento County; and Sandy Beach County Park, near Rio Vista, Solano County (Hagen 1986). Both locations also are reported to support populations of the Sacramento anthicid beetle (Hagen 1986). The closest known population, at Grand Island, is approximately nine miles west of the project area.

Methods - No specific surveys for the Antioch dune beetle were undertaken; rather, during other survey efforts, observers conscious of habitat requirements watched for suitable habitat (riverine dunes).

Results - No suitable habitat for the beetle was identified during survey efforts. Analysis of aerial photographs and recent soil mapping identified 2 to 3 acres of remnant dune habitat north of Lambert Road, between Snodgrass Slough and the Southern Pacific Railroad grade.

Valley Elderberry Longhorn Beetle

Status - The Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) is listed by the USFWS as threatened.

Background - The Valley elderberry longhorn beetle (VELB) is a parasite specific to the elderberry tree (*Sambucus* spp.), a common component of riparian woodlands in the Central Valley of California.

Historically, VELB range has been considered to extend from the Sacramento Valley to the Upper San Joaquin Valley. Before 1980, the majority of collections had been made from Putah Creek and the American River (Sacramento, Yolo, and Solano Counties). Linsley and Chemsak (1972) reported an early collection from as far south as the Merced River (Merced County). The specimen has since been misplaced, but Chemsak (pers. comm.) believes this collection to have been made in the mid-1960s.

In addition to collected specimens, emergence holes in elderberry shrubs (created by emergence of new adults) are now considered to constitute evidence of VELB occurrence. Since 1980 (when the beetle was listed as threatened), extensive field work has been conducted utilizing emergence holes. This work indicates a much larger known range, but still represents a widely s. ttered distribution.

Recent work by Halstead (pers. comm.) indicates a significant southern and elevation range extension for the VELB. He reports new occurrences from Coarsegold (Madera County, elevation 2,200 feet), from King's River near Centerville (Fresno County), from the San Joaquin River (near Fresno) and near Lake Kaweah (Tulare County).

Known VELB range has been extended to include the Sacramento River, from Tehama County to Sacramento County (Jones & Stokes Associates 1987); the Feather River (Yuba County) (Franzreb pers. comm.), several small tributaries to the American River (Placer County) (CNDDB 1988), and Cache Creek (Yolo County) (Singleton pers. comm.). In the Sacramento/San Joaquin River Delta, VELB evidence is reported from near the Old and Middle Rivers (Arnold pers. comm., CNDDB 1988). South of the Delta, VELB evidence has been previously reported from all major drainages down to the Merced River (Arnold pers. comm., CNDDB 1988, Singleton pers. comm., Sutter pers. comm.).

Combined with the recent records by Halstead (pers. comm.), these reports describe known VELB range to be the Central Valley, between Tehama and Tulare Counties, to elevations of 2200 feet.

To date, the closest reported VELB occurrences to the North Delta project area are those from Old and Middle Rivers (CNDDB 1988) and those from the Cosumnes River (CNDDB 1988, Sutter pers. comm.).

The beetle spends the majority of its two-year lifespan in larval development within the elderberry tree (Craighead 1923 <u>in</u> Linsley and Chemsak 1972). Adults, readily observed due to their distinctive orange/black coloration, are usually present only for a short period (approximately 1-2 weeks, during late spring/early summer).

After pupation, emergence of the adult beetle is simultaneous with the spring flowering of the elderberry (Singleton pers. comm.). During this time they feed upon foliage and flowers, and they mate. Eggs are deposited on foliage, on leaf petioles, or in crevices in the bark of the elderberry tree (Eya 1976).

<u>Methods</u> - Due to the specificity of the beetle for the elderberry and the large proportion of the beetle's lifespan spent within it, the primary survey method for VELB is identification of elderberry plants. If plants are located, secondary survey methods include canvassing of plants for adult emergence holes. Surveys were conducted by automobile, by boat, and on foot to cover areas potentially impacted by the five alternatives currently under consideration.

<u>Little Potato Slough and Little Connection Slough</u> - This area was surveyed by vehicle on 5/26/89, and by boat on 6/2/89.

<u>Sacramento River at Georgiana Slough</u> - This area was surveyed by vehicle on 5/26/89. Where elderberry were observed, they were canvassed for emergence holes.

Mokelumne River - This area was surveyed by boat on 5/10/89 and 6/2/89, and on foot on 6/7/89. A follow-up survey was conducted on 12/30/88 and 11/17/89 to canvass plants for emergence holes.

Steamboat Slough and Sutter Slough - This area was surveyed by vehicle on 5/26/89. Where elderberry were observed, they were canvassed for emergence holes.

North Fork and South Fork Mokelumne Rivers - This area was surveyed by vehicle on 12/30/88 and 5/26/89, and by boat on 5/10/88 and 6/2/89. Where elderberry were observed, they were canvassed for emergence holes.

New Hope Cross Channel - This area was surveyed by vehicle on 5/19/88 and 5/20/88. Examination of plants for emergence holes was conducted on 12/14/88 and 12/27/88, when foliage and surrounding brush had died back.

Results

Little Potato Slough and Little Connection Slough - No elderberry were observed in the area potentially impacted by this alternative.

Sacramento River at Georgiana Slough - No elderberry plants were observed in the area potentially impacted by this alternative.

Mokelumne River - Elderberry was widely distributed and relatively dense along both sides of the Mokelumne River between Interstate 5 and New Hope Landing, where it was a common component of the mixed riparian woodland which borders this reach. Plants of all age classes were represented. Elderberry is common on both sides of the levee along the Mokelumne River upstream of I-5 to Dry Creek. Approximately[3] 90 plants were identified on the landside of the levee (Appendix C-9)[4]. One exhibited a single emergence hole of approximately 1-2 years of age (Appendix C-9). Due to this evidence, and the proximity of these plants to other reported occurrences along the Cosumnes River, elderberry in this reach should be considered potential and/or actual VELB habitat.

Steamboat Slough and Sutter Slough - Twenty-four plants were identified on the perimeters of Sutter and Grand Islands adjacent to Sutter and Steamboat Sloughs (Appendix C-10). None occur within the anticipated one-mile reach potentially impacted by this alternative.

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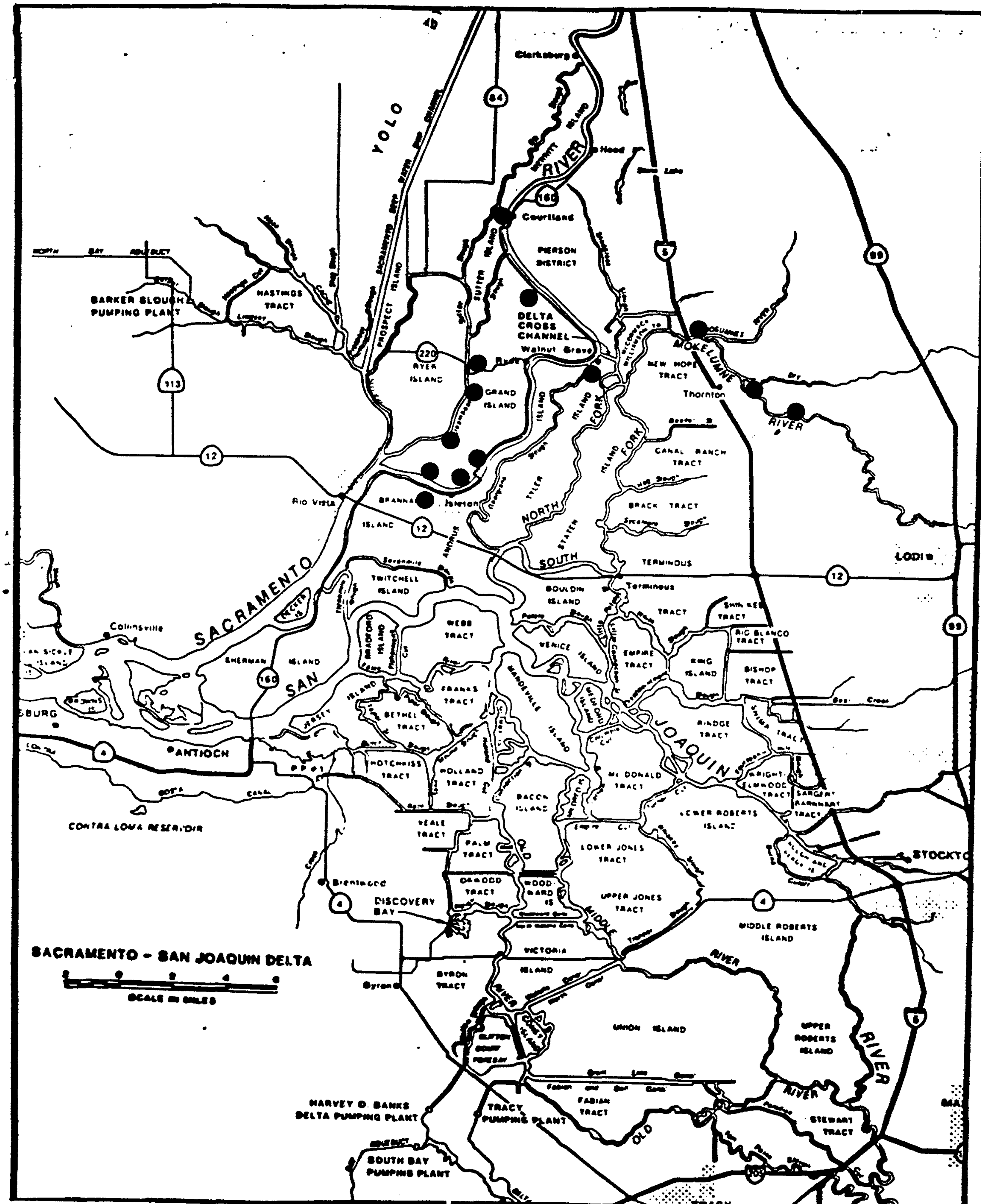
[3] The use of the term "approximately" here denotes no uncertainty as to coverage of the area, or locations of plants, but indicates the difficulty in identifying distinct individuals, due to variable morphology.

[4] For clarity of mapping at this scale, only landside elderberry are depicted.

North Fork and South Fork Mokelumne Rivers - Only a few widely-scattered elderberry were located along the South Fork of the Mokelumne River between New Hope Landing and Terminous (Appendix C-12). No riparian woodland remains in this reach, except immediately south of the Walnut Grove Road crossing. A single elderberry plant was identified on the east side of Tyler Island approximately 1.5 miles downstream from Dead Horse Island (Appendix C-11). Due to its proximity to other reported occurrences, this plant should be considered potential VELB habitat.

New Hope Cross Channel - Areas currently supporting elderberry include the banks of Snodgrass Slough, Lost Slough, and Dead Horse Cut, the perimeter of Dead Horse Island, the Staten Island levee north of Walnut Grove Road, and scattered locations along Highway 160 between Snodgrass Slough and Hood (Appendix C-12).



Distribution of Swainson's Hawk Territories A25

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Table _. Potential Effects of Georgiana Slough Barrier Plan. Special Status Species.

Common Name	Status	Study area 1	Study area 2	Study area 3
Mason's lilaeopsis	FC2,SR	P	P	Y
California hibiscus	FC2	P	P	Y
Delta tule pea	FC2	P	P	Y
Sanford's arrowhead	FC2	P	Y	Y
Aleutian Canada goose	FE	P	P	P
Greater sandhill crane	ST	P	P	Y
Swainson's hawk	ST	P	Y	P
Black rail	FC1.ST	P	P	P
Tricolored blackbird	FC2	P	P	P
Giant garder snake	FC2,ST	P	P	P
Western pond turtle	FC2,CSC	P	P	Y
California tiger salamander	FC2,CSC	N	N	N
California red -legged frog	FC2,CSC	N	N	N
Valley elderberry longhorn beetle	FT	N	N	N

Study Area 1: Sacramento River and Georgiana Slough confluence involves project construction area

Study Area 2: Steamboat Slough and Sutter Slough

Study Area 3: North and South forks of the Mokelumne River

Status
CSC = California species of Special Concern
FE = Federally endangered
FT = Federally threatened
FC1 = Federal, catagory 1 candidate
FC2 = Federal, catagory 2 candidate
ST = State threatened
SR = State rare

Presence
N = No
Y = Yes
P = Potential

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